Regional Operational Plan SF.2A.2020.03

Anchor River Chinook and Coho Salmon and Steelhead Stock Assessment, 2020–2024

by

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May 2020

Alaska Department of Fish and Game   Divisions of Sport Fish and Commercial Fisheries

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN SF.2A.2020.03

OPERATIONAL PLAN: ANCHOR RIVER CHINOOK AND COHO SALMON AND STEELHEAD STOCK ASSESSMENT, 2020–2024

by

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Signature Page

Project Title:	Anchor River Chinook and coho salmon and steelhead stock assessment, 2020–2024
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Approval

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ABSTRACT

In 2020–2024, Chinook salmon (*Oncorhynchus tshawytscha*) will be enumerated at 2 Anchor River sites from mid-May through early August to monitor escapement for the drainage. The south fork site, located at approximately river kilometer (RKM) 4.0, will be monitored by an Adaptive Resolution Imaging Sonar (ARIS) during high flow periods, and a resistance board weir fitted with underwater video will be used thereafter. The north fork site, located at about RKM 5.3, will be monitored by a resistance board weir with underwater video from the beginning of the Chinook salmon run in early May. Motion-detection technology will be used at each weir to record fish passage 24 hours per day. Weekly beach seine surveys will be used to capture Chinook salmon for age-sex-length (ASL) samples downstream of the confluence of the south and north forks. Chinook salmon data will be used to update estimates of the spawner-recruit relationship and harvest rate, and to provide inseason run information to managers. Coho salmon and steelhead will also be monitored in the fall of each year using the resistance board weir and video system on each fork. Coho salmon age, sex, and length will be collected via beach seining. Coho salmon escapement and harvest rate will be estimated along with an index of steelhead abundance and catch rate.

Key words: Anchor River, Chinook salmon, *Oncorhynchus tshawytscha,* coho salmon, *Oncorhynchus kistuch,* run timing, diel timing, sustainable escapement goal, SEG, stock status, weir, underwater video, sonar, ARIS, steelhead, *Oncorhynchus mykiss*.

PURPOSE

This study assesses the Anchor River Chinook salmon (*Oncorhynchus tshawytscha*) stock by monitoring annual escapement (the Anchor River has a sustainable escapement goal [SEG] of 3,800 to 7,600 Chinook salmon), age and sex composition, run timing, and harvest rate. These data are needed to estimate the Chinook salmon spawner-recruit relationship, which is used to estimate an escapement goal range that is likely to produce sustainable yield close to the maximum. Daily weir counts are also used for inseason management by projecting escapement based on historical run timing. Information gathered on the Anchor River Chinook salmon stock is also used to make management decisions for the other lower Kenai Peninsula roadside stream Chinook salmon sport fisheries and the nearby Upper Cook Inlet Chinook salmon summer sport fishery in salt waters.

Additionally, this study will enumerate coho salmon (*Oncorhynchus kistuch*) escapement on the Anchor River, which will allow estimation of run size, and along with fishery harvest data, harvest rate and productivity of this stock. These metrics will allow for more active inseason management and provide information on run size to anglers. Finally, the fall steelhead (*Oncorhynchus mykiss*) run will be enumerated, which, along with fishery catch data, will allow managers to assess the population size and catch rate of this stock.

BACKGROUND

The Anchor River is located on the southern portion of the Kenai Peninsula (Figure 1), and along with Deep and Stariski creeks and the Ninilchik River, they compose the Lower Cook Inlet (LCI) roadside streams. The Anchor River watershed is approximately 587 km^2, with about 266 river kilometers (RKM) of anadromous streams, which supports the largest freshwater sport fishery in the LCI Management Area (Booz et al. 2019). There are 2 major forks of the Anchor River. The south fork Anchor River watershed is approximately twice the size of the north fork Anchor River watershed. Primary species targeted in the sport fisheries are Chinook salmon, coho salmon, steelhead, and Dolly Varden (*Salvelinus malma*). The Anchor River has been monitored primarily for Chinook salmon, although the other commonly targeted sport fish species have periodically been enumerated as well.

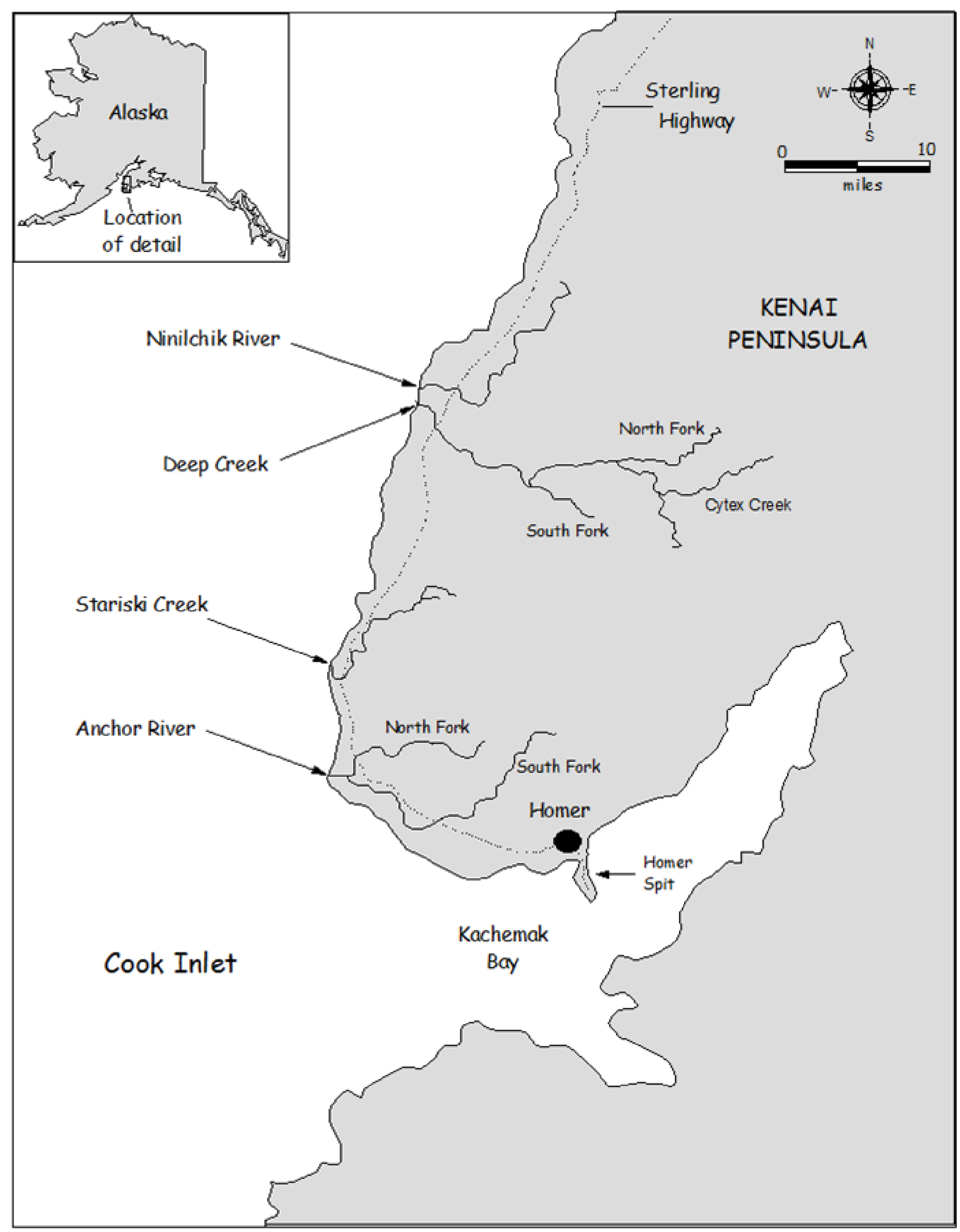

Figure 1.–Location of the Anchor River and other Lower Cook Inlet roadside streams.

CHINOOK SALMON

The LCI roadside streams provide some of the earliest freshwater Chinook salmon sport fishing in Southcentral Alaska. Chinook salmon return to LCI roadside streams from approximately early May through late July, with a peak in early June, though later run timing has been observed in recent years (Dickson and Manishin *In prep*). The characteristics of these Anchor River Chinook salmon fish fit the classification of early-run Chinook salmon as described by Groot and Margolis (1991). The Anchor River has the largest Chinook salmon run of the LCI roadside streams (Booz et al. 2019).

Escapement Monitoring

Chinook salmon escapement has been monitored in the Anchor River since 1962. Through 2002, a single annual aerial survey was flown over a standard section of river during peak spawning season in late July to index Chinook salmon escapement. In 2003, an escapement monitoring project using a dual frequency identification sonar (DIDSON) was conducted in May and June at a mainstem river site approximately 2.8 RKM (approximately 2 miles) from the mouth (Kerkvliet et al. 2008; Figure 2). Since 2004, Chinook salmon escapement has been monitored using sonar during high discharge rates (during May and sometimes through mid-June) and then via a resistance board weir once river levels subside (Kerkvliet et al. 2008). In 2009, 2014, and 2015, sonar was not required because low water levels allowed for the immediate installation of the resistance board weir, which allowed for a census of Chinook salmon escapement in those years (Kerkvliet and Booz 2012; Kerkvliet and Booz *In prep*; Kerkvliet et al. *In prep*). From 2004 through 2010, Chinook salmon were monitored through the resistance board weir with a livebox operation, where fish were manually counted. Beginning in 2011, the weir was fitted with an underwater video system ("video weir") that records motion-detected fish passage.

Figure 2.–Chinook salmon escapement monitoring sites on the Anchor River.

In 2013, high flows substantially altered the river at the mainstem site and rendered it unusable for weir installation. As a result of the erosion, the sonar was temporarily installed approximately 300 m downstream of the traditional site (Kerkvliet and Booz 2018b). Once flows subsided and new weir sites were located, separate weirs were installed on the north fork and south fork by mid-June (Figure 2). The south fork video weir site was about 500 m upstream from the mainstem site. The north fork site was about 1,500 m upstream of the mainstem site and a fixed picket weir with an instream video system was used. A resistance board weir with instream video has been used on the north fork since 2015. Flows on the north fork have been low enough to allow for installation of the resistance board weir by the second week of May in all years since 2015. Escapement monitoring on both forks of the Anchor River has shown the Chinook salmon escapement on the south fork to be larger in all years except 2014 (Table 1). Aerial surveys have shown that very little spawning occurs in the reach between the two weir sites (Kerkvliet and Booz 2018b).

Table 1.–Anchor River Chinook salmon escapement, harvest estimates and rates, and catch estimates and rates, 2003–2019.

			Escapement					
Year	Site	Method	Total	Percent south fork	Harvest[a]	Catch[a]	Harvest rate	Catch rate
2003	mainstem	DIDSON	9,238	–	1,011	4,311	0.1	0.42
2004	mainstem	DIDSON–weir	12,016	–	1,561	5,561	0.11	0.41
2005	mainstem	DIDSON–weir	11,156	–	1,432	5,028	0.11	0.4
2006	mainstem	DIDSON–weir	8,945	–	1,394	4,638	0.13	0.45
2007	mainstem	DIDSON–weir	9,622	–	2,081	9,792	0.18	0.84
2008	mainstem	DIDSON–weir	5,806	–	1,486	3,245	0.2	0.45
2009	mainstem	Weir	3,455	–	737	2,296	0.18	0.55
2010	mainstem	DIDSON–video weir	4,449	–	364	889	0.08	0.18
2011	mainstem	DIDSON–video weir	3,545	–	573	1,227	0.14	0.3
2012	mainstem	DIDSON–video weir	4,509	–	38	189	0.01	0.04
2013	mainstem, south fork, north fork	DIDSON–video weir	4,401	–	97	423	0.02	0.09
2014	south fork, north fork	Video weir	2,499	46	203	926	0.08	0.34
2015	south fork, north fork	Video weir	10,241	64	344	1,159	0.03	0.11
2016	south fork, north fork	DIDSON–video weir	7,142	66	1,384	4,232	0.16	0.5
2017	south fork, north fork	DIDSON–video weir	5,811	76	845	2,888	0.13	0.43
2018	south fork, north fork	DIDSON–video weir	3,195	70	40	305	0.01	0.09
2019	south fork, north fork	DIDSON–video weir	5,630	62	–	–	–	–
Averages								
2003–2008			4,833	–	1,494	5,429	0.14	0.50
2009–2013			4,072	–	362	1,005	0.09	0.23
2014–2019			5,753	64	563[b]	1,902[b]	0.08[b]	0.29[b]

[a] Source: Alaska Sport Fishing Survey database [Internet]. 1996–present. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (accessed Feb. 2020). Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/.

[b] 2014–2018

Historically, all fish passage during sonar monitoring was assumed to be Chinook salmon, and steelhead were believed to introduce minimal bias to the sonar counts. However, it is likely that progressively later run timing of Chinook salmon into the Anchor River has resulted in larger proportions of steelhead in the sonar counts. Early season fish passage at the north fork video weir during south fork sonar operation has been observed to be primarily steelhead movement and not Chinook salmon passage in recent years (2017–2019; Dickson and Manishin *In prep*). From 2017 to 2019, the sonar fish images on the south fork were assumed to be steelhead until the north fork video showed a decreasing trend in steelhead upstream passage and Chinook salmon were also observed (Dickson and Manishin *In prep*).

The date on which south fork sonar counts were assumed to be Chinook salmon was 2 days earlier than the date on which the fish passage trends changed on the north fork. This 2 day difference was chosen due to observed differences in the average day the 25th percentile of Chinook salmon passage occurred at each weir in 2015 (a year with complete count via weir), 2016–2017, and 2019. The timing of Chinook salmon passage in 2014 and 2018 were not considered because passage was anomalously late in timing and low in escapement. No adjustment in the date of Chinook salmon enumeration on the south fork was made for 2016 because Chinook salmon were observed consistently on the north fork starting on the first day the weir was installed. We believe our treatment of the south fork sonar counts in the manner above is the best compromise to remove unwanted early steelhead counts while accommodating Chinook salmon passage.

Biological Sampling: ASL and Hatchery Composition

Since 2014, Chinook salmon age-sex-length (ASL) and origin (wild or hatchery-reared) samples have been collected from weekly beach seine surveys on the mainstem from mid-May through mid-July. The methods used to collect these samples have been refined over the duration of weir escapement monitoring (Kerkvliet et al. 2008; Kerkvliet and Booz *In prep*). Prior to 2014, ASL and origin samples were collected using beach seine surveys on the north fork and south fork early in the season and at the weir using livebox capture later in the season. It was difficult to collect adequate samples sizes using a livebox because Chinook salmon were reluctant to enter, which necessitated attempts to capture fish in the livebox during peak diel movement (midnight through 4:00 AM).

From 2016 to 2019, beach seine catches on the mainstem during sonar operation have ranged from 1 to 9 Chinook salmon, typically less than 1% of the Chinook salmon sonar estimate (Dickson and Manishin, *In prep*). These small catches were partially due to high water conditions that make beach seining difficult to impossible early in the season and because of the small number of Chinook salmon present in the mainstem section during the early part of the run. During the lower water years of 2014 and 2015, age compositions prior to 30 May and after 30 May were not statistically different, although sample sizes for the early strata were still small (Kerkvliet and Booz *In prep*; Kerkvliet et al. *In prep*). The fewer fish in the early part of the run mitigates, to some extent, any bias incurred by sampling the latter part of the run more intensely.

For 2020 through 2024, we plan on a single beach seine above the south fork weir site to obtain a better ASL sample of fish counted through the sonar period; see Methods for details.

Sampling Bias

Beach Seine vs. Weir

Sampling bias between beach seine samples and fish passage through the weir has been evaluated in 3 ways: 1) comparing Chinook salmon sex compositions, 2) comparing proportions of Chinook salmon <508 mm total length, and 3) comparing the proportion of all Chinook salmon from 3 total length size categories (small: <508 mm; medium: ≥508 mm and <711 mm; or large: ≥711 mm). In some years, there was no significant difference in the size and sex compositions between sampling methods. It was determined that during years in which the sex compositions differed, the bias was inherent in assessing sex via video image. As such, sex composition has not been assessed via video since 2018.

North Fork vs. South Fork

Until 2014, north fork and south fork beach seine samples taken during the sonar period were pooled; we found inconsequential differences between the age compositions in samples taken from each fork during that time frame.

More recently, comparisons of the length compositions between the north fork and south fork escapements via video images have not shown meaningful differences. In years that the size composition of Chinook salmon less than or greater and equal to 508 mm total length was assessed via video image (2014–2019), there was no significant difference between the weirs in 2015–2017 and in 2019 (Dickson and Manishin, *In prep*). In 2019, three total length (TL) categories were assessed via video image (small <508 mm, medium ≥508 mm and <711 mm, and large ≥711 mm). The size composition was statistically significantly different between weirs, but the differences were small and not biologically meaningful (small: 0.09 north fork and 0.08 south fork; medium: 0.12 north fork and 0.15 south fork; large: 0.80 north fork and 0.76 south fork). The small difference between the north fork and south fork size compositions shows any selectivity for north fork or south fork fish during mainstem beach seining will not affect the ASL composition to any meaningful degree. It also allows for reasonable extrapolation of biological composition data between forks.

Management

The management approaches for Chinook salmon sport fisheries in the Anchor River (and other LCI roadside streams) have been conservative throughout most of their history due to a lack of high-resolution or timely escapement data. Inseason escapement data became available when the Anchor River sonar-weir project began estimating Chinook salmon escapement in 2003. Since 2003, the Anchor River Chinook salmon sport fishery has been more actively managed. The fishery has experienced a series of regulation changes through the Alaska Board of Fisheries (BOF) and by emergency order (EO) in response to large runs from 2003 through 2008 and poor runs from 2009 through 2014. The current fishery structure of five 3-day weekends (Saturday through Monday) and Wednesdays from late May to mid-June was established in 2008 (Szarzi et al. 2010). Since 2008, the fishery has been restricted by preseason or inseason EO in 9 of 11 seasons.

Inriver Sport Fishery

The annual days fished on the Anchor River, as well as Chinook salmon harvest and effort, have varied through periods of high and low productivity, and regulation changes through the BOF process and by EO. Effort, catch, and harvest in the inriver sport fishery are estimated by the ADF&G Statewide Harvest Survey (SWHS). After a period of high productivity in the early 2000s, low productivity from 2009 to 2015 necessitated EO restrictions on the fishery. Average angler days for all Anchor River fisheries dropped to 13,095 from over 20,000 in the previous decade (Booz et al. 2019). Average Chinook salmon harvest and catch were reduced from the 2003–2008 average of 1,494 and 5,429, respectively, to the 2009–2013 average harvest of 362 and catch of 1,005 (Table 1). In 2016 and 2017, Anchor River Chinook salmon harvest and catch briefly increased to levels greater than the 2009–2013 average, but in 2018, harvest and catch (40 and 305 Chinook salmon, respectively) were well below the historical average due to inseason closure of the fishery after Memorial Day weekend (Table 1). In 2019, the fishery was restricted preseason to 3 weekends and Wednesdays and gear was limited to single-hook, no bait. Angler effort appeared to be low (ADF&G staff observations). Inriver harvest rates averaged 14% during from 2003–2008, 9% during the lower productivity years of 2009–2013, and 15% during 2016 and 2017 (Table 1). Catch rates averaged 50% during from 2003 to 2008, 23% from 2009 to 2013, and 47% during the brief improvement in run size of 2016 and 2017 (Table 1).

Sustainable Escapement Goal

The SEG for Anchor River Chinook salmon has been refined as annual escapement data have become available. In 2004, an SEG based on aerial index counts was discontinued. From 2005 to 2007, the Anchor River Chinook salmon sport fishery was managed without an escapement goal. In the fall of 2007, ADF&G conducted a spawner-recruit analysis using all available data and established a lower bound SEG of 5,000 for Anchor River Chinook salmon. In 2010, ADF&G updated the spawner-recruit model with escapement and harvest data and modified the goal to an SEG range of 3,800–10,000 Chinook salmon. The lower end of the SEG range was the point estimate for maximum sustained yield, and the upper bound was the estimated carrying capacity. In 2016, the spawner-recruit model was updated using aerial survey data from 1997 through 2008, available weir escapement, age and harvest data, and assumed marine harvest rates (Otis et al. 2016). A new SEG range of 3,800–7,600 fish was established.

COHO SALMON

The Anchor River supports a road-accessible coho salmon fishery that has variable harvest, catch, and angler effort. The run size and timing of the Anchor River coho salmon stock has also been highly variable. Most Anchor River coho salmon spend 2 years rearing in fresh water before they smolt, and spend 1 year feeding in the ocean before they return to spawn; i.e., they are predominantly age 2.1 on return. They enter fresh water as adults from late July through mid-September, with peak run timing in late August to early September (Hammarstrom 1981).

Escapement Monitoring

ADF&G has periodically monitored coho salmon escapement in the Anchor River since the late 1980s. Escapement was last enumerated in 2011 (Table 2), although 2005, 2006, and 2009 should not be considered full enumerations due to weir failures or operation dates in those years. The runs in 2008 and 2011 may also have been underestimated, but likely not substantially so. Escapements were highly variable both in size and run timing. During the historical weir operations, coho salmon escapement ranged eightfold, from 2,409 in 1987 to 20,187 in 1989. The escapements in the 2000s ranged from 5,728 in 2004 to 18,977 in 2005 (Table 2). The SWHS has also assessed coho salmon harvest since 1977 and catch since 1990.

Table 2.–Anchor River coho salmon and steelhead counts and exploitation rates from 1987–1989, 1992, and 2004–2011.

				Coho salmon				Steelhead	
Year	Project dates	RKM	Method	Escapement[a]	Harvest[b]	Catch[b]	Harvest rate	Count[a,c]	Catch[b]
1987	05 Jul–11 Sep	2.5	weir	2,409	2,010	ND	0.45	136	520
1988	03 Jul–06 Oct	2.5	weir	2,805	2,219	ND	0.44	878	643
1989	06 Jul–07 Nov[d]	2.5	weir	20,187	2,635	ND	0.12	769	200
1992	04 Jul–02 Oct	2.5	weir	4,596	2,267	4,850	0.33	1,261	2,720
2004	15 May–13 Sep	3.9	DIDSON–weir	5,728	4,383	10,194	0.43	20	3,710
2005	13 May–09 Sep	3.9	DIDSON–weir	18,977[e]	5,314	11,639	–	107	2,524
2006	15 May–24 Aug	3.9	DIDSON–weir	10,181[e]	3,920	7,634	–	4	4,513
2007	14 May–12 Sep	3.9	DIDSON–weir	8,226	3,962	9,881	0.33	325	8,365
2008	13 May–12 Sep	3.9	DIDSON–weir	5,951	4,790	7,658	0.45	258	8,733
2009	12 May–11 Sep	3.9	weir	2,692	3,882	6,332	0.59	85[f]	4,119
2010	12 May–28 Sep	3.9	video weir	6,014	2,863	4,799	0.32	586	2,018
2011	13 May–21 Sep	3.9	video weir	1,866	808	1,275	0.30	132	401

[a] Source:Larson et al. 1988; Larson and Balland 1989; Larson (1990-1995, 1997) when weir was located at approximately RKM 2.5 and Kerkvliet and Booz (2018a) when weir was located at approximately RKM 3.9.

[b] Source: Mills (1988-1990, 1993); Alaska Sport Fishing Survey database [Internet]. 1996–present Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (accessed Feb. 2020). Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey.

[c] Incomplete counts due to project operation dates and (or) weir location in all years.

[d] Weir overtopped for 26 days from September 18 to November 7.

[e] Incomplete counts because project operation dates did not encompass the entire run.

[f] Count updated.

Biological Sampling

From 2004 to 2009, ASL composition of the coho salmon run was based on a systematic sample collected from the livebox on the mainstem weir. During these years, the most common life history pattern was 2 years in freshwater followed by 1 year at sea, which composed at least 80% of the escapement in all years. On average, females composed 46% of the escapement (Kerkvliet et al. 2008; Kerkvliet and Burwen 2010; Kerkvliet et al. 2012; Kerkvliet and Booz 2012). In 2010, biological sampling was discontinued upon the transition to a video weir and due to consistency in the one life history type.

Management

There are no biological or sustainable escapement goals (BEG and SEG) or management plans for any LCI coho salmon stocks, including the Anchor River (Booz et al. 2019). The Kenai Peninsula roadside streams sport fisheries are managed through Kenai Peninsula Area general provisions (Alaska Administrative Code 5 AAC 56.120), which specify seasons, bag and possession limits, and special provisions (5 AAC 56.120), which describe gear and area. Coho salmon are within regulations for salmon other than Chinook salmon. There is no annual limit, but a daily bag limit of 2 coho salmon in freshwater.

Inriver Sport Fishery

The Anchor River coho salmon fishery begins in August when coho salmon enter freshwater, often after fall rains that bring river levels up (Szarzi et al. 2007). Salmon fishing is restricted to the lower 2 miles of the river. Gear is restricted to 1 unbaited, single-hook artificial lure from 1

September until the Anchor River closes to fishing on 1 November. Effort, catch, and harvest in the inriver sport fishery are estimated by the SWHS. Since the last escapement count in 2011, Anchor River coho salmon harvest has declined from the historical (1990–2010) average of 3,273 to an average of 1,137 from 2011–2018 (Booz et al. 2019). Based on angler reports and periodic observations made by ADF&G staff, the water conditions and fishing success in the Anchor River was generally poor in 2011–2013 and 2016. The coho salmon harvest of 651 in 2016 was the lowest since the inception of the SWHS in 1977 (Booz et al. 2019: p. 117). Harvest and catch rates can be calculated in years with reliable escapement estimation. Exploitation has ranged from 12% in 1989 to 59% in 2009, though this harvest rate may be biased high due to incomplete run enumeration in 2009 (Table 2).

STEELHEAD

The Anchor River supports a popular and road-accessible catch-and-release only steelhead fishery. These steelhead are fall-run iteroparous (can spawn more than once) anadromous fish that spend 2 to 3 years rearing in fresh water as juveniles, return to fresh water as adults from late July through November, spawn from April to May, and emigrate after spawning during May and June (ADF&G 1990). Anchor River studies in 1989 and 1990 found about 19% of the spawning steelhead population were spawning for at least the second time (Larson and Balland 1989; ADF&G 1990; Larson 1993).

Escapement Monitoring

Steelhead in the Anchor River have never been fully enumerated, but the partial counts of kelts (post-spawn steelhead emigrating from the system) and immigrating steelhead indicate run sizes are variable and typically small (Table 2). The most complete counts occurred in 1988 and 1992 at a weir operated to count Dolly Varden approximately 2.5[1] RKM from the river mouth (Larson and Balland 1989; Larson 1990; Larson 1993). During these years, steelhead were counted through 6 October and 2 October and 878 and 1,261 fish were counted, respectively (Table 2). Although a weir was in the river until 7 November in 1989, it was compromised after 18 September and then removed. In spring 2009, 605 steelhead kelts were enumerated moving downstream at the 3.9 RKM mainstem weir (Kervliet and Booz 2012: p. 66). In 2010, a partial immigration count of 586 steelhead was produced from a video weir at 3.9 RKM operated through 29 September (Table 2).

Management

There are no biological or sustainable escapement goals (BEG and SEG) or management plans for any LCI roadside stream steelhead stocks, including the Anchor River. The regulatory framework for the roadside stream steelhead fishery has evolved over time and is currently guided by the *Criteria for Establishing Special Management Areas for Trout* (5 AAC 75.013). The steelhead fisheries in the LCI roadside streams, including the Anchor River, have been catch-and-release only since 1989. Only 1 unbaited, single-hook, artificial lure has been allowed in the streams beginning 1 September since 1991. From 1996 to 2010, each stream was opened to fishing through 31 December. Since 2011, the streams have closed on 1 November.

[1] River kilometers were remeasured in 2013; previous reports cite this location as RKM 1.6. The weir was located in Dudas Hole, near the Anchor River field site cabins.

Inriver Sport Fishery

Prior to prohibiting retention of steelhead, the average annual estimated harvest by the SWHS from 1977 to 1988 was 1,119 steelhead (Kerkvliet et al. 2016: p. 129). The SWHS has estimated catch of steelhead since 1990. Most of the steelhead fishery occurs in the fall when fish return to the streams to overwinter and continues until the rivers freeze up in late October, or until the fishery is closed by regulation on 31 October. A small amount of the annual catch is incidentally hooked by anglers targeting Chinook salmon in the spring. Most angler effort on the roadside streams for steelhead occurs on the Anchor River, although catch has declined from the 1989–2010 average of 4,120 steelhead annually to 2,321 steelhead caught annually from 2011 to 2018 (Booz et al. 2019: p. 123). Catch has declined since 2011, probably because of the shortened season with the closure on 1 November instead of 1 January.

OBJECTIVES

The main component of the Anchor River stock assessment project in 2020–2024 is the enumeration and sampling of the Chinook salmon escapement. Coho salmon escapement will also be enumerated and sampled, and an index of steelhead abundance will be obtained. The primary and secondary objectives are as follows:

PRIMARY OBJECTIVES

1) Estimate the Anchor River Chinook salmon escapement upstream of RKM 4.1 on the south fork and upstream of RKM 5.4 on the north fork such that the combined estimate is within 5% of the true value 95% of the time[2].
2) Estimate the age and sex composition of the Chinook salmon escapement into the Anchor River within 10% of the true values 95% of the time.
3) Census the Anchor River coho salmon escapement upstream of RKM 4.1 on the south fork and upstream of RKM 5.4 on the north fork.
4) Estimate the age and sex composition of the escapement of coho salmon into the Anchor River within 10% of the true values 90% of the time.
5) Census the fall Anchor River steelhead escapement upstream of RKM 4.1 on the south fork and upstream of RKM 5.4 on the north fork.

SECONDARY OBJECTIVES

1) Estimate mean length-at-age (mid eye to tail fork) of the escapement of Chinook and coho salmon into the Anchor River.
2) Examine between-reader and within-reader variation of the Adaptive Resolution Imaging Sonar (ARIS) counts used to estimate the escapement when the ARIS counts represent more than 25% of the total escapement count.
3) Determine diel and cumulative run timing of Chinook salmon, coho salmon, and steelhead on both the north and south forks of the Anchor River.

[2] Within d% of the true value A% of the time" implies $P\left(p_i - \frac{d}{100} \leq \hat{p}_i \leq p_i + d/100\right) = A/100$ where p_i denotes the population age proportion for age class i.

4) Examine the effects of water temperature and stage height on Chinook salmon, coho salmon, and steelhead cumulative run timing on both the north and south forks of the Anchor River.
5) Estimate the composition of Chinook salmon origin (wild vs. hatchery-reared) in the Anchor River.
6) Census the length composition of the small, medium, and large (<508 mm; ≥508 mm and <711 mm; ≥711 mm TL) Chinook salmon in video weir counts at RKM 4.1 and beach seine catches.
7) Estimate the exploitation rate for Chinook and coho salmon stocks and a catch rate for steelhead.

METHODS

The main components of this project are as follows:

1) escapement monitoring of Chinook and coho salmon, and steelhead
2) biological sampling of Chinook and coho salmon.

ESCAPEMENT MONITORING

Chinook and coho salmon escapement will be enumerated primarily with a video weir on each of the north and south forks of the Anchor River. Steelhead escapement upstream of the weir sites will also be enumerated; it is noted that there may be a substantial number of steelhead that overwinter downstream of the weirs. Operation will begin in early May and continue through October or freeze-up on both forks, whichever comes first. The south fork site is located at about RKM 4.1 and the north forksite is located at RKM 5.4. If spring high water prevents installation of the south fork video weir, a sonar system with a fixed-picket weir will be operated until flows subside (Figure 2) and a video weir will be installed about 10 m downstream of the sonar system as early as possible. The video weir will be installed on the north fork as soon as flows allow (late April at the earliest), which is typically before Chinook salmon migration begins. These methods have resulted in relative precisions (95%) ranging from 2 to 6%, generally within the precision criteria of Objective 1. Progressively later run timing and the use of sonar estimation only on the south fork rather than the mainstem should ensure that a very small portion of the escapement is enumerated using sonar.

South Fork Sonar

Operation

An ARIS model 1200 with a high-resolution lens (Appendix A1) will be used to monitor escapement in the south fork if flows prevent the installation of the video weir. If the ARIS is not available or is needed by another escapement project midseason, a dual frequency identification sonar (DIDSON) will be used. Both the ARIS and the DIDSON will be configured and set up preseason so the transition from ARIS to DIDSON, if necessary, will be efficient. The ARIS sonar beam length is customizable up to 30 meters without losing high resolution, so it will be the preferred method. For specifics on DIDSON operation, reference the 2017–2019 Anchor River operational plan (Kerkvliet and Booz 2017).

The ARIS will be operated at high frequency and mounted on a Sound Metrics Corporation (SMC) AR2 pan-and-tilt rotator for remote aiming. The sonar and rotator will be deployed in the river using an aluminum H-style mount. A partial fixed-picket weir (up to 28 meters long) will be installed on the left bank just downstream of the ARIS to constrict fish passage (Figure 3). This partial weir will extend at least 2 m farther offshore of the ARIS to deflect fish through the sonar's insonified zone (Figures 3 and 4). River depth and water velocity will determine the distance the partial picket weir can be extended. All bottom irregularities at the base of the picket weir will be sealed with sandbags. To ensure constant power, the ARIS system will be operated using a 12 V DC power system that includes up to 1,300 Ah of battery life, a 600 W inverter, a 1,000 A battery charger, solar panels, and a 2000 W gasoline generator. A voltage meter will be used to monitor the charge of the system.

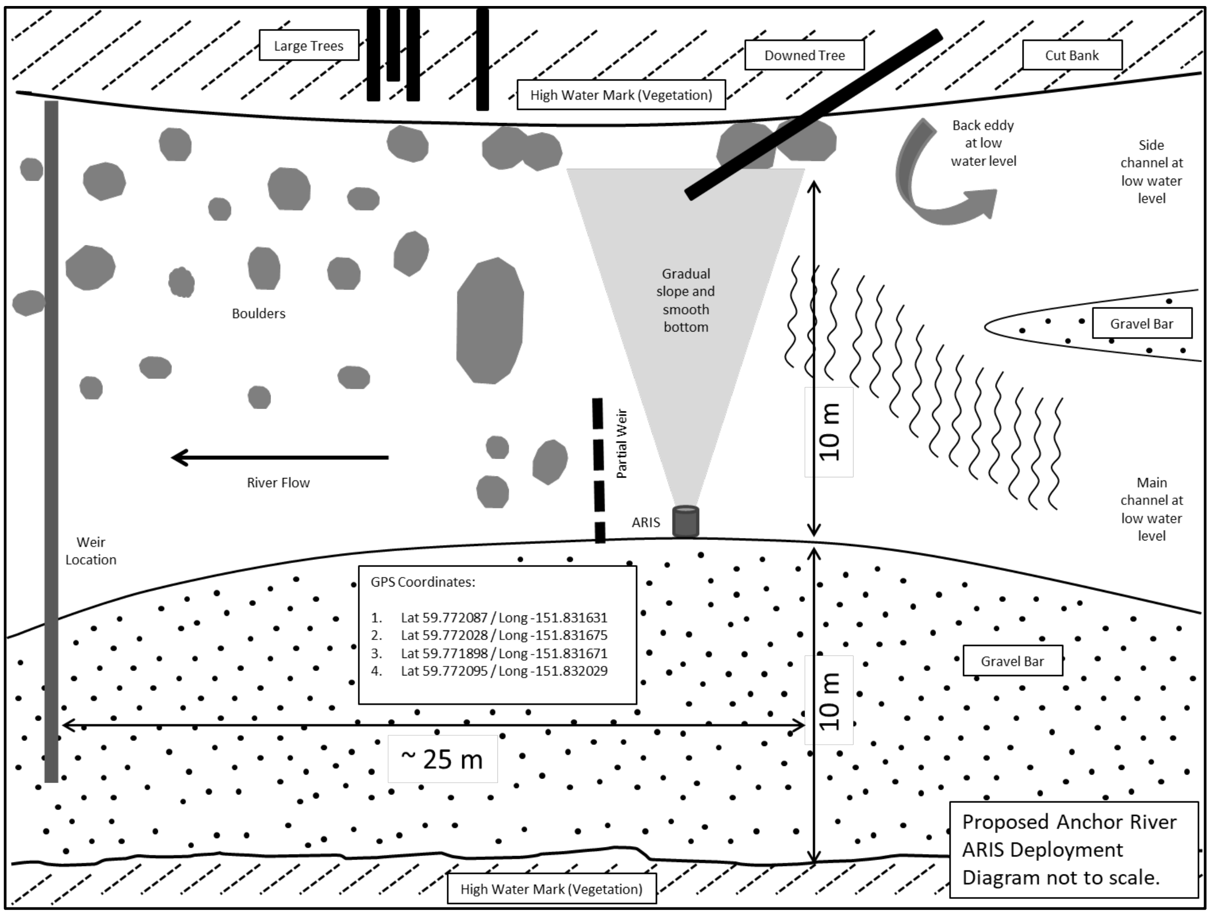

Figure 3.–Anchor River south fork weir and ARIS locations.

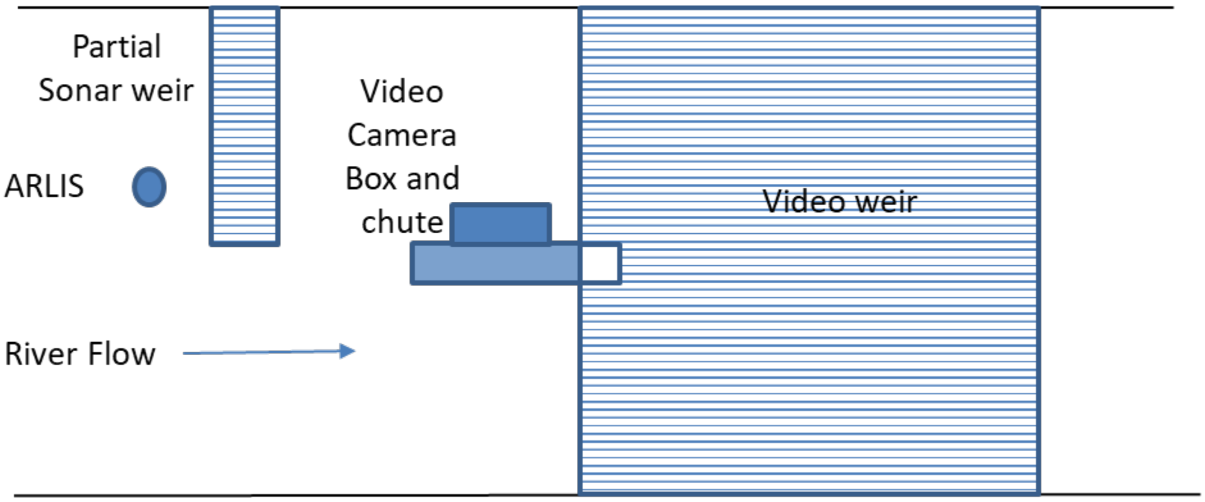

Figure 4.–Configuration of the partial fixed-picket weir and the video weir on the south fork Anchor River.

ARIS data collection software (ARIScope version 2.6.2) will be used for adjusting sonar aim, changing settings, and programming and recording sonar files. Throughout the monitoring period, fish passage will be recorded continuously into three 20-minute increments for each hour. GoToMyPC[3] Remote Access software will be used to ensure the ARIS software is continuously recording. ARIS files will be saved automatically to uniquely named files by date and time and backed up onto 2 external hard drives. ARIS postprocessing software (ARISFish V2.6.2) will be used to manually count fish images (Appendix A2).

Fish images will be counted by direction (up and downstream) from the first 20-minute recording of each hour. In the event of a software malfunction resulting in the first 20 minutes of the hour not being recorded, the recording from the second or third 20-minute period will be used. The net fish count (upstream passage less downstream passage) in the first 20 minutes will then be expanded to the full hour. The hourly expanded counts will then be summed to estimate daily passage of Chinook salmon over the duration of the ARIS operation. We assume that the biases associated with using expanded counts compared to complete counts will be low based on comparisons of both methods at the Anchor River (Kerkvliet et al. 2008). Details on counting sonar files, and recording and entering data, are in the Data Collection section below.

The technician on duty will check that the computer is functioning properly and the ARIS software is recording frequently throughout the day and during the night as needed, particularly during times when fish passage is high or expected to be high. The following information will be checked to ensure data are being collected: the sonar icon in the upper left corner says "recording" in red letters, frames are advancing correctly under "File Position," and the settings (frame rate, window length, and window start) are correct.

Data Collection

The Chinook salmon escapement during the sonar period on south fork will be estimated by assuming all upstream and downstream images are Chinook salmon, but only after north fork

[3] Product names used in this report are included for completeness and do not constitute product endorsement.

species composition data are inspected (see Background section above and Sonar Count Adjustment section below for details).

The first 20-minute file from each hour will be reviewed using the ARISFish software. This software allows the user to review sonar files while viewing video mode and Echogram mode simultaneously. Technicians will review each mark on the Echogram screen to determine if it is a fish, and if its movement is upstream or downstream. The video mode will help technicians determine if the fish entered the insonified beam from the upstream or downstream side, and which side it exits the beam. All fish will be marked as upstream, downstream, or neither on the Echogram screen. ARISFish software produces a .txt file for each sonar file counted that summarizes the upstream, downstream, and neutral fish marks. Technicians will use those summaries to tally hourly upstream and downstream counts on a data sheet (Appendix B1) and enter them into the Anchor River field Microsoft Access database using the data entry structure detailed in Appendix C1. The daily net counts (upstream minus downstream) and expanded counts will be automatically summarized with a query in the Access field database.

ARISFish will also be used for technicians to complete between-reader and within-reader counts. These counts will be used in season to calibrate both counters to each other and for crew leaders to ensure that counting methods between the 2 crew members are similar. The between and within counts will be used postseason to estimate variability in estimates if the sonar is used to estimate more than 25% of the total escapement. Three 20-minute files from each day will be used for within and between counts. The files will be predetermined, based on hours that typically have some fish passage (so as not to recount files that have zero fish movement). The between-reader files will be recounted by a crewmember that did not do the initial count, whereas the within-reader files will be recounted by the crewmember that did the initial count. These data will also be entered into the Anchor Riverfield database using the data entry structure outlined in Appendices C1–C3.

ARIS files will be backed up every 12 hours by creating a copy on a second external hard drive. During each new shift, crewmembers will review the data collected during the prior shift for completeness. Postseason, all data will be imported into a master Access database at the Homer office.

Sonar Count Adjustments

Counts may be adjusted in 3 ways: 1) All counts made for less than 20 minutes in an hour will be expanded to a full 20 minutes and then to the full hour; 2) missing hourly counts, caused by high water, computer malfunctions, or unreadable files, will be interpolated based on counts before and after the data gap (see interpolation section below); and 3) postseason, if we believe that early sonar counts have been contaminated by steelhead migration, we may adjust the date at which we begin accumulating Chinook salmon counts. In 2020–2024, the assumption that all fish images are Chinook salmon on the south fork sonar will be made once the observed trend in the north fork video fish passage indicates that the steelhead movement has mostly ceased and Chinook salmon are the dominant species being counted through the south fork weirs. An approximate 2-day lag will be used (south fork sonar counts will be assumed Chinook salmon 2 days prior to the observed change at the north fork video weir), unless observed run timing or other environmental conditions suggest a different time-lag should be used. Technicians counting steelhead at the north fork weir will make conscientious efforts to identify unique steelhead and avoid counting the same steelhead multiple times as they mill about prior to spawning.

Video Weirs

Weir Design

Video weir installation at both sites will be initiated by attaching a rail to the substrate using upstream duckbill earth anchors pounded into the river bottom using a rock hammer. All attachment eyes on the rails will be connected to a duckbill earth anchor (Stewart 2003). The gaps between the weir pickets will be approximately 3.8 cm (about 1.5 inches) to block the passage of all but the smallest ocean-age-1 Chinook salmon. Stewart (2002) will be used as a guide for weir material construction and repairs. A fish passage chute with an underwater video system will be attached to the upstream edge of the south fork and north fork weirs at the most optimal sites for both fish passage and camera box placement (Figures 4 and 5).

In May and June, steelhead will be emigrating from the Anchor River. Fixed-picket steelhead wings will be attached to the upstream side of the north fork video weir (Figure 5) to direct all steelhead passage through the video system. This will allow for accurate estimation of steelhead timing on the north fork, which will be used to inform the start date for accumulation of Chinook salmon sonar counts (see above). The wings will guide emigrating steelhead through the video system and provide an accurate count of steelhead movement through the north fork video weir. Once a video weir is installed on the south fork, a "steelhead chute" will be formed by weighting the downstream end of a weir panel with a sandbag. The placement of the sandbag will be adjusted to allow steelhead to swim downstream and to prevent immigrating fish from swimming upstream over the panel undetected. We believe the number of Chinook salmon, coho salmon, and immigrating steelhead using the steelhead chute to pass downstream will be negligible based on video recordings of the chute in 2009, when only 5 Chinook salmon were observed going downstream through the chute from 13 May to 25 June (Kerkvliet and Booz 2012). The steelhead chute will be removed by removing the sandbag once the steelhead emigration is complete in June.

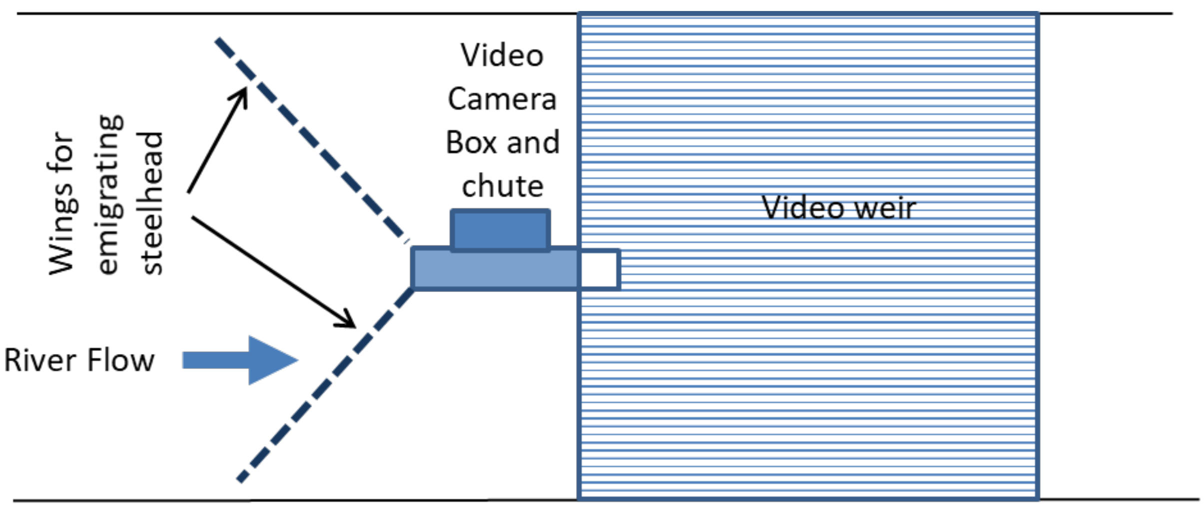

Figure 5.–Configuration of video weir with steelhead wings on the North Fork Anchor River.

The underwater video system is composed of an underwater camera mounted in a sealed box (camera box), fish passage chute, 12 V DC power system, and video recording system. The camera box is roughly 80 cm by 90 cm and is constructed with 3.2 mm aluminum. The camera mounts in the rear and at the bottom of the camera box and is pointed towards the front through the 45 cm by 80 cm and 9.5 mm thick safety glass. At least 6 LED lights are installed within the camera box for consistent illumination throughout the day. After the camera and lights are installed, the camera box is filled with dechlorinated tap water through a hatch for increased video quality, protection from silt, and to maintain negative buoyancy. The hatch is located on the top of the box above the camera and sealed with a rubber gasket and bolts to prevent any river water from entering the box. A small amount of algaecide is added to the water to help prevent algae growth inside the box. The camera and light cords are fed through a sealed tube on top of the camera box that extends well above the water line.

The camera box attaches to the fish passage chute by fitting into welded pins. The fish passage chute is roughly 1 m long, has a removable lid to block out most light, and restricts passage down to roughly 20 cm. The fish passage chute is attached to a fence that sits against the rail on the substrate and has an opening that aligns with the opening at the upstream end of the floating fish passage chute panel. The passage chute is attached to the fence by threading three-eighths inch metal rods through sleeve fittings on the chute and fence. The removable lid on the passage chute allows the outside of the camera box glass and the inside of the fish passage chute to be cleaned. The backdrop of the fish chute will be marked with 2 sets of 2 vertical lines 508 mm apart and 711 mm apart to allow Chinook salmon to be categorized into the 3 total length groups described in Secondary Objective 2 (<508 mm, ≥508 mm and <711 mm, or ≥711 mm).

The 12 V DC power system is the same one used for the sonar system and will power the camera, lights, and the video recording system, which consists of a digital video recorder (DVR) capture card within the desktop computer.

Operation

During Chinook salmon enumeration (May through July), a weir crew member will be stationed at the Anchor River field site and will run the generator as needed to recharge the power system. A crew member will not be stationed at the field site for August through October. To reduce the number of trips that need to be made to the field site, a second battery bank with the same components described in the sonar section will be added to the south fork video weir system. The components requiring power (computer, camera, and camera box lights) will be split between the 2 power systems so that power consumption is less and requires less frequent generator recharges.

All video images will be recorded on a 2 terabyte internal hard drive that is specialized for recording video at 30 frames-per-second. Motion detection software provided by the DVR manufacturer will be used to record video on 3 channels. One channel will only record motion triggers, a second channel will record the full 3:00 AM hour, and the third channel will record video 24 hours each day. The software will be used to customize the areas of the frame that trigger motion in order to minimize the amount of blank video footage and review time.

A MiFi will be used to create a wireless internet connection and allow remote access to the computer via the GoToMyPC program for remote check-ins and video data review. Remote access to the computer will also allow crew to monitor the physical condition of the weir via a security camera feed that will run on a fourth DVR channel. All motion-triggered video and the full 0300 hour video will be uploaded to a cloud-based service, such as Microsoft OneDrive, each day so the files can be reviewed at a field camp or at the Homer office. The computer used for most of the video review (i.e., the computer in the Anchor River field site) will be programmed to automatically sync all video from the north fork and south fork weirs via the cloud.

Data Collection

The full 0300 hour and the 0300 hour of just motion triggers will be the first video footage reviewed daily. Accumulated motion triggers will be examined for the hour and compared to the actual number of fish observed during the full hour. In the event a Chinook salmon did not create a motion trigger during that hour in May through July, or a coho salmon or steelhead in August through October, the technician will immediately alter the motion trigger detection areas and (or) sensitivity in the DVR software to remedy the problem. Then, the technician will discuss with their crew and project leaders which additional hours may require review of the full record footage. After reviewing the 0300-hour full record and motion files, all motion-recorded files will be reviewed sequentially, beginning with the 0000 hour.

While reviewing steelhead passage for the north fork in May, technicians will be particularly conscientious of steelhead with identifying marks so as to avoid counting the same steelhead multiple times.

The DVR software Remove ViewLog has numerous file review features that assist in identification and counting of passing fish. The image can be played forwards or backwards at various speeds or paused and zoomed to assist in counting or species identification. All hourly Chinook salmon, coho salmon, and steelhead counts will also be tallied by total length size class (<508 mm, ≥508 mm and <711 mm, or ≥711 mm) and presence or absence of the adipose fin. All other species will be tallied as daily totals. Sex will not be recorded.

All escapement counts will be collected on video data sheets (Appendices B2 and B3) and then entered into the Access database using the data entry structure detailed in Appendix C2. Daily fish counts will be summarized in Access, and daily fish counts will also be summarized in season automatically using an Access query. During each new shift, crewmembers will review the data collected during the prior shift for completeness. Postseason, all data will be imported into a master Access database at the Homer office.

In order to prevent data loss, the DVR software will be set to record video files to a folder synced to upload to Microsoft OneDrive. The folder will be located on an internal hard drive that is formatted to accommodate constant recording of video files. In the event of a software or cloud malfunction, the video files will be available on the internal hard drive and the motion detected video files will be available on both the cloud and the internal hard drive. Recording video to 2 locations should significantly reduce the possibility of video data loss.

Daily Weir Crew Operations

A crew will be stationed at the Anchor River field camp during Chinook salmon enumeration (May through July). Coho salmon and steelhead counting will primarily occur remotely, with frequent visits to clean weirs, perform routine maintenance, and ensure constant power to the video systems.

An outline of the daily and weekly weir crew schedule during Chinook salmon enumeration can be found in Appendix D1. The duties for the entire duration of weir monitoring will include the following:

1) Inspect both weirs to ensure to fish cannot migrate upstream undetected.
2) Ensure that the sonar and (or) video is recording and functioning properly.
3) Clean the weirs of debris.

4) Scrub the outside of the camera box glass clean at least once per shift.
5) Troubleshoot any problems with the MiFi connection, sonar, DVR recording, cloud storage, or computer that cannot be addressed remotely.
6) Keep the power systems operating, run the generators as needed, and service the generators at appropriate intervals.
7) Complete sonar between-reader and within-reader counts.
8) Tally daily video escapement counts by hour for Chinook salmon, coho salmon, and steelhead. All Chinook salmon will also be tallied by presence or absence of adipose fin and size class. Tally other species as daily counts.
9) Enter hourly and daily counts into the Access field database and Microsoft OneDrive spreadsheets. Update biologists and other crew with escapement counts.
10) Assist with beach seine surveys, field camp maintenance and cleanup, data proofing, and other management area projects as needed.

Interpolating Counts: Sonar and Video

If any period of video or sonar files are lost, unusable, or not recorded, the missing time period will be recorded in the Access Anchor River field database in the missing sonar-video table. The table will be referenced inseason and postseason to determine if interpolation is needed and is very important because it is difficult to discern which periods of video or sonar were not recorded without detailed notes.

In the event interpolation is required for 1–2 consecutive missing 20-minute sonar files, 2 countable hours, 1 immediately before and 1 following the uncounted period will be counted completely (i.e., the full 60 minutes of each of the 2 hours will be counted) to help mitigate any increased variance or bias that the interpolation incurred. Interpolated full-hour counts for hour j (24-hour system) will be made according to the following:

$$\hat{I}_j = C_k + \left[\frac{C_m - C_k}{m - k}\right][j - k] \tag{1}$$

where

C_x	=	count in hour x, where x is either m or k,
k	=	last full hour (24-hour system, e.g., 1500) for which a count is available ($j > k$),
m	=	next full hour (e,g, 1700) for which a count is available ($j < m$).

A similar interpolation is required for 1–2 hours of video: the motion files from 1 hour immediately before and following the missing video period will be counted. It is likely this method will be used rarely because missing periods of video that short may often not require interpolation. If it’s determined that the short missing period was in the middle of a period of high fish passage, then this method may be appropriate.

Should data be missing for 3 hours or more for either sonar or video, such that diel timing begins to affect the interpolation, then the counts from the same time of day on the day prior and day after the day in which the missing time period occurs will be used. For example, if the missing data are from 0300 through 1100 hours on Tuesday, then the missing data will be interpolated as the average of the counts from 0300 through 1100 hours from Monday and Wednesday. With this method, only the first 20-minute file of each ARIS hour will be counted (rather than the full 60 minutes). Other factors may be taken into consideration to produce the most accurate interpolation, including rising or falling stream levels, water temperatures and weather, and sport fishery pressure downstream of the weirs.

Finalizing Escapement Data

As the season progresses, weir crew and crew leaders will proof the datasheets against the field database. When mistakes are found, they will be modified in the field database immediately. If the change alters the daily escapement, then the change will be made on the OneDrive spreadsheet and an email will be sent to the project biologists and the office staff that updates the inseason projection and online counts. This will help keep the records of the counts consistent and reduce confusion.

Postseason, the counts will be imported into the master Access database at the Homer office. Counts must match the paper data sheets, as well as the online counts and inseason projections. Counts will be further proofed by size class for each fork of the Anchor River and diel timing. These data are not considered final until the Fishery Data Series report workbook is updated for the year, which will be done as timely as possible after the season to prevent using preliminary escapement numbers for longer than is necessary.

Run Timing

Escapement counts of Chinook salmon, coho salmon, and steelhead will be summed by the hour to assess the diel fish passage of all 3 species over the course of the season. Daily counts of all 3 species will be used to assess cumulative run timing. The effects of water depth and temperature on the daily and cumulative timing will also be assessed.

Origin Composition

All Chinook salmon that pass through the video weirs or are captured in a beach seine survey will be examined for the presence or absence of an adipose fin. The proportions of hatchery-reared Chinook salmon in the sonar beach seine survey samples and in the video footage will be weighted by the proportions of the Chinook salmon escapement estimated during each period (sonar and weir).

Size Category Composition

All Chinook salmon that pass through the video weirs or are captured in a beach seine survey will be examined for total length category (small <508 mm, medium ≥508 mm and <711 mm, or large ≥711 mm). The Chinook salmon escapement estimated with sonar will be weighted with the proportions of total length categories of the Chinook salmon captured in beach seine surveys during the sonar period and combined with the census of total length categories observed at the video weirs.

Water Temperature and Stage Height

Water temperature data will be collected with an Onset Hobo Tidbit at both weirs. The device will be contained in perforated plastic housing and attached to the downstream handle of the camera box or sonar with chain and a shackle. The Tidbit will collect water temperature readings in Celsius once per hour. The temperature loggers will be downloaded periodically throughout the season to ensure the data are not lost and there is no lapse in coverage during the season. Water temperature readings from the Hobo Tidbits will be exported in degrees Celsius and stored in a Microsoft Excel file on Microsoft OneDrive during the season, and backed up into the Water Data folder on the O drive at the Homer office postseason.

Stage height will be collected for the south fork with a gauge operated by United States Geological Survey (USGS) at the New Sterling Highway Road Bridge (RKM 11.4). The data will be requested from USGS and stored in the Water Data folder on the O drive at the Homer office for further analyses with south fork run timing.

Stage height will be collected for north fork using water pressure (psi) readings from an Onset Hobo U20L-04 Water Level Data Logger deployed on a staff gauge just upstream of the north fork weir. The device will be secured to the staff gauge with cable and cable clamps. Readings with a survey level will be taken prior to installation and at removal to ensure the staff gauge has not shifted positions. Water pressure readings will be converted to stage height using the Barometric Compensation Assistant plugin with the Onset software by incorporating atmospheric pressure (mbar) from the nearby meteorological station managed by KBNERR[4]. Final water depth readings will be stored in the same manner as the water temperature data.

BIOLOGICAL SAMPLING

Beach seine surveys will be used to collect samples to estimate age, sex, and length (ASL) and origin (hatchery vs. wild) composition of Chinook and coho salmon escapements, and to better understand how steelhead utilize the holding water downstream of the weirs in the Anchor River.

Beach Seine Survey Methods

The following guidelines will be followed to minimize handling stress when sampling the beach seine: 1) fish will not be removed from water unless necessary, 2) each fish will be processed as quickly as possible, and 3) a recovery area for the fish will be provided.

Prior to deploying the beach seine from the raft, 1 crew member will be designated to record data onto data sheets (Appendix B4) and secure the net on the beach while other crew members work up the fish. The remaining crew will work in pairs.

Two to 3 crew members wearing dry suits will work the beach seine in pools (Figure 6). Experienced crew members will partner with new crew members during the surveys to ensure ASL sampling methods are conducted properly (Appendix E2). Crew members sampling Chinook salmon will clearly tell the crew member recording the data the following, in order: adipose fin, sex, mid eye to tail fork (METF) length, and total length size classification (small <508 mm, medium ≥508 mm and <711 mm, or large ≥711 mm). For coho salmon, the same order will be used but there will be no total length classification. The crew member holding a sampled fish will orient the Chinook or coho salmon with its left side facing up so the sampler can easily remove scales from the preferred area (Welander 1940; Appendix E1). The fish holder will keep a firm grasp on the caudal peduncle, keep the gill plates underwater, the fish as flat as possible to provide

[4]Kachemak Bay National Research Reserve. http://cdmo.baruch.sc.edu/dges/

the most accurate METF measurement, and keep the preferred area out of the water when the sampler is pulling scales.

The scales will be placed on a neoprene wrist cuff while sampling fish out of the net, and then temporarily stored in labeled scale boxes. The sampler will confirm with the data collector that they are starting and ending with the same box and cell combination the data collector has recorded. Any discrepancies between the sampler and data collector will be resolved before moving on to the next hole to beach seine. Other species will be tallied in each survey. The pre- or postspawn condition of female steelhead will be identified based on external examination.

Scale boxes will be kept in a waterproof box in the raft between sets to prevent water from mixing up scale samples.

All Chinook salmon missing an adipose fin will be sacrificed to be processed for the presence of either coded wire tags (CWT) or thermal marks to identify release location. Heads that are positively identified with a CWT wand will have a CWT cinch strap assigned to them. Two otoliths will be collected from adipose finclipped Chinook salmon that do not possess a CWT. Fillets or headed gutted whole fish will be donated to charity the day of the survey.

The scales will be mounted to gum cards as soon as possible after the surveys. Data will also be proofed, resolved, and entered into the netting Excel file as soon as possible. Following each day of beach seining, the crew will hang the beach seine to dry and will inspect the webbing for holes and the cork and lead line for loose attachments and repair as needed.

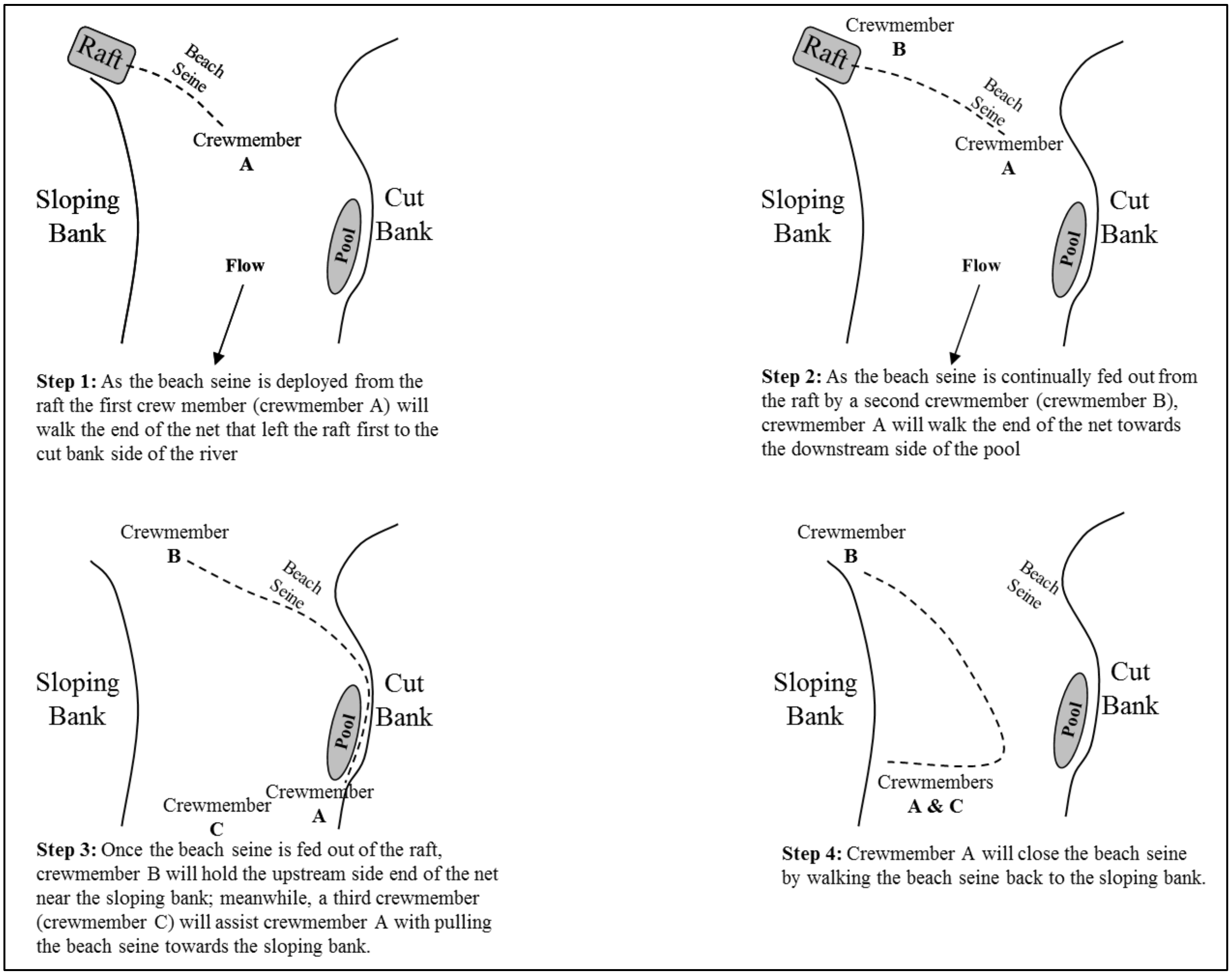

Figure 6.–Beach seining method for sampling the Anchor River.

Sample Collection

Chinook salmon and coho salmon will be sampled for ASL using the following methods. Steelhead will be counted and immediately released.

Age

Three scales will be removed following the methods of Welander (1940) and Scarnecchia (1979). If scales are not present on the left side preferred area, then the right side preferred area will be used as an alternate (Appendix E1). Scale samples will be placed on gum cards with the first 3 scales placed on numbers 1, 11, and 21; the second 3 scales on numbers 2, 12, and 21, etc. Scale cards will be numbered sequentially (1, 2, 3…n + 1) by species. Scale cards will be prelabeled before sampling. After sampling, scales will be inspected to ensure their cleanliness and orientation before mounting. Common problems encountered with inexperienced scale collectors are listed in Appendix E2.

Gum cards will be impressed into cellulose acetate cards (Clutter and Whitesel 1956). Age will be determined from pressed scales using procedures described by Mosher (1969). Before determining age, the scale reader will be given a reference set of 200 scales for age determination from a historical data set. Age will be determined from scales following the criteria described in Appendix E3.

Ages determined from the test set by the scale reader will be compared to the previous (reference) age estimates. Ages that do not match will be reviewed and the scale re-read. Once the reader ages are resolved and equal to the test set ages, then the reader will begin with the collected samples from the current season. Age estimates will be produced without knowledge of size, sex, or other age estimates. Age will be determined from each scale sample twice to estimate within-reader precision. All scale samples that had conflicting ages for the 2 estimates will be re-aged to produce a resolved age that will be used for composition and abundance estimates.

Sex

Sex will be determined by external physical characteristics, such as kype development, or a protruding ovipositor.

Length

Length measurements will be made from mid eye to tail fork (METF) to the nearest 5 millimeters. Chinook salmon samples will be binned into 1 of the 3 total length size classes (<508 mm; ≥508 mm and < 711 mm; ≥ 711 mm). When a METF measurement translates to a TL measurement that is close to the TL cutoff of 508 mm or 711 mm (approximately >460 mm and <500 mm METF or >650 mm and <700 mm METF), a TL length measurement will be taken to ensure the fish is assigned the correct TL category.

Hatchery marks and tags

The Chinook or coho salmon heads of all positive CWT detections while using a tag wand in the field will be given a unique numbered cinch strap. All data will be recorded on ADF&G Mark, Tag, and Age Laboratory CWT forms and entered in the field database (Appendices F1 and F2); heads will be sent to the Mark, Tag, and Age Laboratory for analysis. The otoliths will be collected for all negative CWT detections from fish missing an adipose fin. The Chinook salmon otoliths will be ground and read for Cook Inlet and Ninilchik release thermal marks at the Homer office.

Beach Seine Survey: Chinook Salmon

Sonar operation period

One beach seine survey will be conducted near the end of sonar operation, beginning at the Black Water Bend location (RKM 11.0) on the south fork and continuing downstream to the south fork weir site (RKM 4.1; Figure 7). Almost all of the Chinook salmon that passed the weir site during sonar enumeration should be staged in this section of river during this time. After meeting the desired sample size (see sample size section below), the survey will continue until the south fork weir site in order to continue assessing the origin composition and to remove as many hatchery-reared Chinook salmon from the escapement as possible.

A second beach seine survey will be conducted from the north fork weir downstream to the confluence of the forks near the end of the sonar period. There is good holding water between the confluence and the north fork weir that will probably hold Chinook salmon during this time, even if the Chinook salmon passage through the north fork weir is very small to date. Only in large or very early runs, however, will the north fork escapement reach 200 by 28 May, the average date the sonar has been replaced with video on the south fork since 2016.

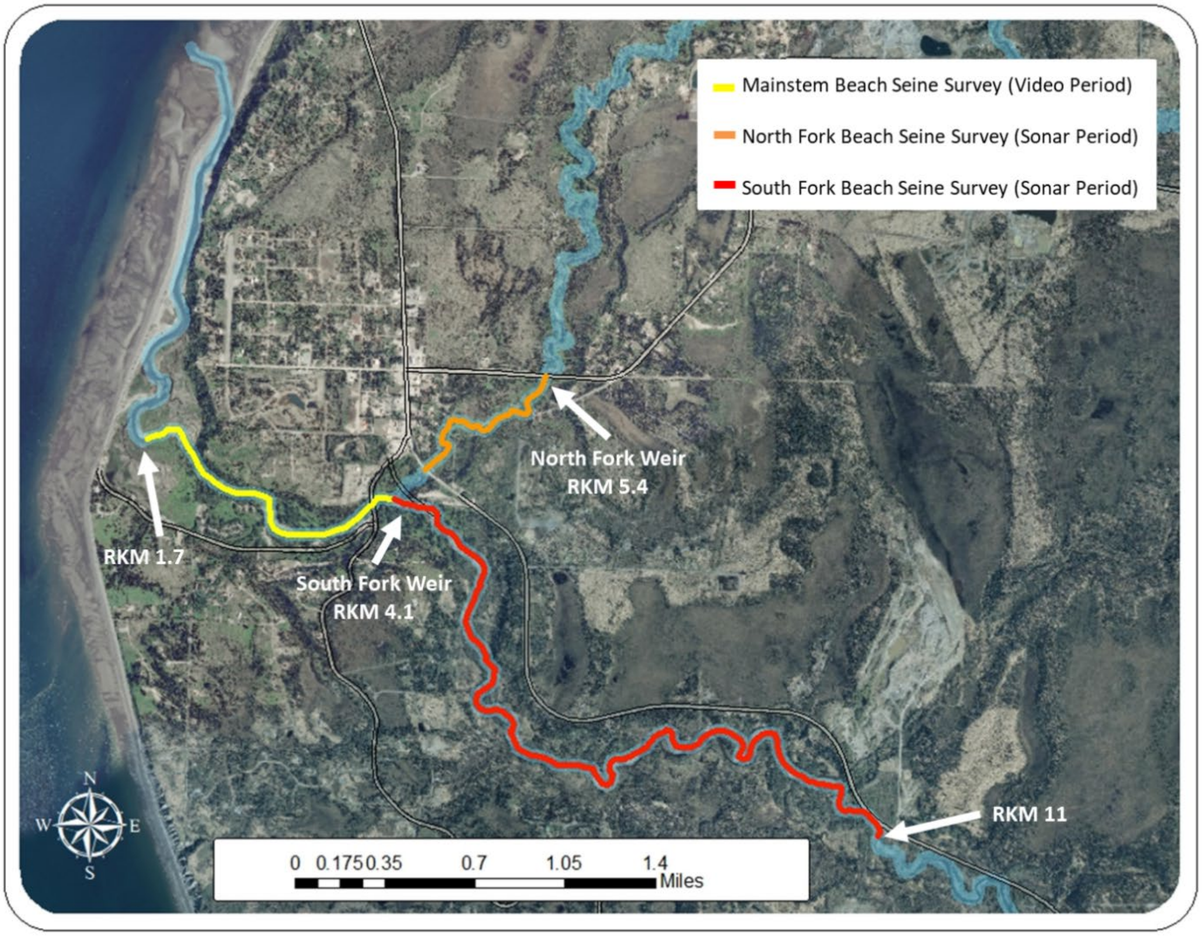

Figure 7.–Anchor River beach seine survey reaches.

Video weir period

Chinook salmon ASL and origin composition data will be collected via weekly beach seine surveys in the mainstem river through May and June when water levels permit safe and effective beach seine operation. Occasionally, water levels are too high to beach seine after a large rain event, but flows typically subside quickly enough to reschedule the survey within the same week. The survey will end once the target sample size for a particular seining operation (see sample size section below) has been reached and all fish captured in the beach seine have been sampled. Weekly surveys will primarily begin at the first pool downstream of the north and south forks confluence (at about RKM 4.0). Pools are characterized by deeper water than surrounding areas and are typical holding and resting areas for Chinook salmon (Groot and Margolis 1991).

Sample size: age-sex composition

The minimum sample size required to estimate the composition of the Chinook salmon escapement by age in relation to Objective 2 criteria was calculated according to Thompson (1987). Note that the sample size needed for sex composition estimation (binomial calculations) will be lower than that needed for age composition estimation for the same objective criteria.

$$n = \frac{n_o}{1 + \frac{n_o - 1}{N}} (1 - R)^{-1} \tag{1}$$

where

- n_o = 127 Chinook salmon (Thompson 1987) of target population, and
- N = total number of Chinook salmon in the target population, and
- R = proportion of unreadable scales.

To determine the number of Chinook salmon scales that need to be collected, we assumed the annual 2020–2024 escapements will be similar to the 2016–2019 average of 5,445 (from Table 1). Assuming age cannot be estimated on 20% of the scale samples, sampling 155 Chinook salmon will allow us to meet the criteria stated in Objective 2. To determine the sampling rate, we took into consideration the highly variable escapements in recent years (range of 2,499 to 10,241 from 2014 to 2019; Table 1) and conservatively estimated the annual escapement to be 3,000 Chinook salmon. A conservative escapement estimate will help ensure we will not fall short of the sample size goal. With this assumption, the anticipated sampling rate to be applied to each survey event will be at least 0.06 (155/3,000). The inseason projection used to anticipate the total escapement based on run timing provides reasonable estimates of projected escapement once about 2 weeks of Chinook salmon enumeration has taken place (approximately 1 June). Based on the inseason escapement projections, the sampling rate will be adjusted annually on 1 June.

Because the age and sex composition of the Chinook salmon run may change as the run progresses, beach seine surveys will be conducted approximately once per week by applying a sampling rate to the cumulative Chinook salmon weir counts since the last sampling event. The last survey will occur before the Chinook salmon begin re-absorbing their scales in July and it becomes difficult to collect readable scales. Given the sampling rate and the number of Chinook salmon caught in beach seine surveys on the mainstem since 2014 (Table 3), the sample size should be easily attainable.

Table 3.–Chinook salmon sample sizes and effort (days) for beach seining in the Anchor River.

Year	Sample size	Effort (days)
2014	263	9
2015	377	8
2016	304	9
2017	223	9
2018	305	11
2019	244	5

For each weekly beach seine survey conducted during video weir operation, the sum of the number of Chinook salmon that were counted at the north fork and south fork weirs since the previous beach seine survey will be multiplied by the appropriate sampling rate and the result rounded up to the nearest whole number.

For the above-sonar beach seine survey, conducted immediately after sonar operation, the number of Chinook salmon estimated to have passed upstream of the sonar will be multiplied by the appropriate sampling rate and rounded up to the nearest whole number. If a beach seine survey is needed in the north fork, the number of Chinook salmon that have passed through the north fork weir from the beginning of weir operation to the survey date will be multiplied by the sampling rate and rounded up to the nearest whole number; the sample size for the south fork in this case will be deprecated accordingly. Beach seining will continue until the required sample size has been met. All fish from every seine haul will be sampled, regardless if the sample size is achieved partway through sampling a haul.

During the sonar operation period, origin composition information will also be estimated via the beach seine survey because this information (adipose fin presence or absence) cannot be distinguished by sonar. A sample of 59 Chinook salmon will be required to estimate the origin composition to within 5% of the true value 95% of the time. Sample size was calculated for a binomial proportion (Cochran 1977) given that hatchery returns averaged 4% (103/2,551) of the run from 2016 to 2019 (Dickson and Manishin *In prep.*).

Beach Seine Survey: Coho Salmon

Two beach seine surveys for coho salmon will be conducted in the same manner as the Chinook salmon surveys, and coho salmon will be sampled in the same fashion as Chinook salmon (Appendix E1). With video weir operation, it is not possible to sample coho salmon evenly throughout the run due to their variable run timing resulting in large pulses of fish passage through the weirs. It is assumed that fish captured during the 2 surveys will be representative of the overall run. Each survey will begin near the Black Water Bend area (RKM 11.0) and progress downstream until the sample size goal is met or until RKM 1.7 on the mainstem (Figure 7). The surveys will be conducted when water conditions allow for successful beach seining and after a sufficient number of coho salmon have passed the south fork video weir so that the survey is likely to capture the sample size within the survey area. One survey will be conducted on or around 21 August (near the historical 25th percentile of the run), and the second survey will probably take place the first week in September (just after the historical 50th percentile of the run).

Sample size: age-sex composition

Coho salmon age and sex variables are both binomial in nature (mostly ages 1.1 and 2.1 and male and female) and sample size was calculated for a binomial proportion (Cochran 1977) while also considering the wide range of historical Anchor River coho salmon escapements. If the escapement is as large as the largest enumerated on the Anchor River (20,187 in 1989; Table 2) and 20% of the scales are unreadable, a minimum sample size of 84 scales will be required to estimate the composition of the coho salmon escapement by age and sex in relation to Primary Objective 4 criteria (Cochran 1977). If the escapement is small and more similar to the lowest-enumerated (2,409 in 1987; Table 2), the required sample size would only be 2 samples less. Given the large number of deepwater pools suitable for holding coho salmon downstream of Black Water Bend (11.0 RKM), the sample size should be easily attainable in 2 surveys.

Beach Seine Survey: Steelhead

Historical radiotelemetry data suggest steelhead may overwinter in deep holes in the lower river. When the video weirs are removed (likely early November) a beach seine survey will therefore also be conducted beginning at each weir site; biological samples will not be taken during this survey. The survey will be used to better understand how steelhead utilize holding water in the lower river and which habitats they use in fall and early winter. The survey will also inform the completeness of the escapement counts at the weirs.

Finalizing Biological Composition Data

The raw beach seine survey data will be entered into an Excel spreadsheet saved on Microsoft OneDrive. Data entry and any sample processing (e.g., scale mounting and pressing) will occur within 1 week of a sampling event. These data will be proofed to match data sheets, ensure that each scale sample has a data entry, and to check the correct number of fish per card and scales per fish were recorded. Additionally, data entries will be examined for discrepancies between possible combinations of METF length, length category, and sex. Once scales have been aged, the mean and standard deviation of length will be calculated by age class. All fish with a length greater than 2 standard deviations from the mean of its age class will be reexamined as a final error check. Next, the data will be entered into the Master Anchor database using the structure outlined in Appendix C3. And finally, the ASL compositions will be incorporated into the Fishery Data Series workbook as part of the process to finalize data postseason.

DATA ANALYSIS

ESCAPEMENT

Chinook Salmon (Objective 1)

Net upstream passage during ARIS operation on the south fork for the counted period in hour j in day i will be calculated as follows:

$$n_{ij} = u_{ij} - d_{ij} \tag{2}$$

where

u_{ij} = upstream count for the counted period in hour j within day i, and

d_{ij} = downstream count for the counted period in hour j within day i.

The total estimated count for day *i* on the south fork will be calculated as follows:

$$\hat{C}_i = P_i \frac{\sum_{j=1}^{p_i} n_{ij}}{p_i} \tag{3}$$

where

p_i = number of (20-minute) counting periods conducted within day *i* (by design = 24), and

P_i = total number of (20-minute) counting periods that could be sampled within day *i* (by design = 72).

The total estimated count for the period covered by the ARIS on the south fork will be calculated as follows:

$$\hat{N}_A = \sum_{i=1}^{L} \hat{C}_i \tag{4}$$

where *L* is the number of days in the season covered by the ARIS counting process.

The variance of the estimated daily count will be calculated as follows (Cochran 1977):

$$var(\hat{C}_i) = \left(1 - {p_i}/{P_i}\right) P_i^2 \frac{s_i^2}{p_i} \tag{5}$$

where s_i^2 is the sample variance for counts within a day, which is approximated using the successive differences estimator appropriate for systematic sampling (Wolter 1985):

$$s_i^2 = \frac{\sum_{j=2}^{p_i} \left(n_{ij} - n_{i(j-1)}\right)^2}{2\ (p_i - 1)} \tag{6}$$

The variance for the estimated count for the entire season covered by the ARIS on the south fork will be calculated as the sum of the daily variances:

$$var(\hat{N}_A) = \sum_{i=1}^{L} var(\hat{C}_i). \tag{7}$$

The estimated total Chinook salmon passage over the entire season for the whole of the Anchor River will be calculated as follows:

$$\hat{N}_{T,Ch} = \hat{N}_A + N_{S,Ch} + N_{N,Ch} \tag{8}$$

where $N_{S,Ch}$ is the count of Chinook salmon through the full weir on the south fork and $N_{N,Ch}$ is the count through the north fork weir; the variance of $\hat{N}_T$ will be estimated as follows:

$$var(\hat{N}_T) = var(\hat{N}_A). \tag{9}$$

Coho Salmon (Objectives 3)

The total passage ($N_{T,Co}$) for coho salmon over the entire season for the whole of the Anchor River will be calculated as the addition of passage through the south fork ($N_{S,Co}$) and north fork ($N_{N,Co}$) video weirs:

$$N_{T,Co} = N_{S,Co} + N_{N,Co} \tag{10}$$

Steelhead (Objectives 5)

The passage ($N_{W,S}$) for steelhead through the weirs over the entire season for the whole of the Anchor River will be calculated as the addition of passage through the south fork ($N_{S,S}$) and north fork ($N_{N,S}$) video weirs:

$$N_{T,S} = N_{S,S} + N_{N,S} \tag{11}$$

READER VARIABILITY (SECONDARY OBJECTIVE 2)

To evaluate between-reader variability, the total upstream, downstream, and net counts of each crewmember will be recounted by a second crewmember for a given set of ARIS files.

The following statistics will be calculated for the between-reader analysis:

1) Kendall's Tau will be used for each pair of readers counting the same files, as well as for all first and second readings. Kendall's Tau ranges from −1 to +1, representing perfect negative and positive correlation, respectively.
2) Intraclass correlation coefficient will be used for each pair of readers counting the same files. This statistic is a function of the correlation and agreement between readers. It ranges from 0 to 1; it is high when there is little variation between the scores given to each file by the readers and vice versa.
3) A Tukey difference plot will be used for each pair of readers counting the same files. These plots are of differences between readers against the average of the scores of the readers.

A within-reader analysis analogous to the statistics in points 1, 2, and 3 above will also be conducted.

AGE AND SEX COMPOSITION: CHINOOK AND COHO SALMON (OBJECTIVES 2 AND 4)

Age and sex samples will be taken from the Chinook salmon escapement in a proportional manner (see details in Methods section), and 2 beach seine surveys will be used to sample the coho salmon escapement.

The estimated proportion of Chinook or coho salmon of age or sex class *k* (or combination of), in the escapement will be calculated by:

$$\hat{p}_{k,Sp} = \frac{n_{k,Sp}}{n_{Sp}} \tag{12}$$

where

Sp = Chinook or coho salmon,

$n_{k,Sp}$ = the total number of salmon of species Sp, age or sex class k in n, and

$n_{,Sp}$ = the number of salmon of species Sp sampled.

The estimated variance of the proportion ($\hat{p}_k, Sp$) will be calculated as follows:

$$var(\hat{p}_{k,Sp}) = \left(\frac{\hat{N}_{T,Sp} - n_{Sp}}{\hat{N}_{T,Sp}}\right) \frac{\hat{p}_{k,Sp}(1-\hat{p}_{k,Sp})}{n_{Sp}-1}, \tag{13}$$

The estimated total number of Chinook or coho salmon of age or sex class k will be calculated as

$$\hat{N}_{k,Sp} = \hat{N}_{T,Sp}\hat{p}_{k,Sp}. \tag{14}$$

The estimated variance of $\hat{N}_{k,Sp}$ will be calculated as follows (Goodman 1960):

$$var(\hat{N}_{k,Sp}) = \hat{N}_{T,Sp}{}^{2}\, var(\hat{p}_{k,Sp}) + \hat{p}_{k,Sp}^{2}\, var(\hat{N}_{T,Sp}) - var(\hat{p}_{k,Sp})\, var(\hat{N}_{T,Sp}) \tag{15}$$

Length by Age and Sex of Chinook and Coho Salmon (Secondary Objective 1)

The mean length and its sampling variance by age and sex will be estimated using standard sample summary statistics (Cochran 1977).

Cumulative and Diel Run Timing (Secondary Objective 3)

The cumulative percent of the escapement will be used to determine run timing of Chinook and coho salmon and steelhead by using the daily escapement from the north fork and south fork weirs by date for each fork and the combined forks. Diel timing of the 3 species will be determined using hourly net expanded sonar and video counts collected for each day at each weir.

Effects of Water Temperature and Stage Height on Cumulative Run Timing (Secondary Objective 4)

Summed daily counts will be used to calculate the cumulative percent for the entire season for each species on each fork. Pearson's correlation (r) and linear regression techniques will be used to examine effects of water temperature and stage height on each species' cumulative percent counts at each weir location.

Origin Composition of Chinook Salmon (Secondary Objective 5)

The proportion of hatchery-reared Chinook salmon in the escapement will be estimated by weighting the proportions of hatchery-reared fish in the beach seining sample during ARIS operation and the proportion of hatchery reared fish from the video footage with estimated respective abundances during each period:

$$\hat{p}_H = \frac{\widehat{N_A}}{\widehat{N_A} + N_{W,Ch}} \hat{p}_{HA} + \frac{N_{W,Ch}}{\widehat{N_A} + N_{W,Ch}} p_{Hw} \tag{16}$$

where

$$N_{W,Ch} = N_{N,Ch} + N_{S,Ch} \tag{17}$$

and

$\hat{p}_{HA}$ = estimated proportion of hatchery-reared fish in the escapement during the ARIS period

p_{HW} = known proportion of hatchery-reared fish in the escapement during the weir period.

The variance of $\hat{p}_H$ will be estimated using a Taylor series expansion (note that all covariance terms in the formula are zero):

$$\begin{aligned} var(\hat{p}_H) = & \frac{\left[\hat{p}_{HA}\left(\widehat{N_A} + N_W\right) - \left(\hat{p}_{HA}\widehat{N_A} + N_W p_{HW}\right)\right]^2}{\left(\widehat{N_A} + N_W\right)^4} var(\widehat{N_A}) \\ & + \frac{\widehat{N_A}^2}{\left(\widehat{N_A} + N_W\right)^2} var(\hat{p}_{HA}) \end{aligned} \tag{18}$$

SIZE CLASS COMPOSITION OF CHINOOK SALMON (SECONDARY OBJECTIVE 6)

The size class composition (<508 mm TL; ≥508 mm and <711 mm TL; ≥711 mm TL) from the beach seine survey during ARIS operation will be used to estimate size composition during sonar operation. Chinook salmon passing through the video weirs will be censused for size class category. A chi-square test of independence between the beach seine method and the weir method with respect to size composition will be conducted. The video weir census and sonar estimate will be summed to estimate the size class composition of the escapement.

HARVEST (CHINOOK, COHO SALMON) AND CATCH RATE (STEELHEAD) (SECONDARY OBJECTIVE 7)

The estimated total harvest for Chinook and coho salmon, and total catch for steelhead, will be obtained from the SWHS. The estimated freshwater harvest for Chinook and coho salmon (F_{Sp}) and index of catch rate for steelhead will be calculated as follows:

$$\hat{F}_{Ch} = \frac{\hat{h}_{Ch}}{\hat{N}_{T,Ch}} \tag{19}$$

$$\hat{F}_{co} = \frac{\hat{h}_{co}}{N_{T,co}} \tag{20}$$

$$\hat{F}_{Sh} = \frac{\hat{h}_{sh}}{N_{T,sh}} \tag{21}$$

where $\hat{h}_{sp}$ is the SWHS estimated sport harvest (Chinook = ch, coho = co) or catch (steelhead = sh) in the Anchor River.

Variance of $\hat{F}_{Ch}$ will be estimated following Goodman (1960) as

$$var(\hat{F}_{Ch}) = \frac{var(\hat{h}_{Ch})}{\hat{N}_{T,Ch}{}^{2}} + \frac{var(\hat{N}_{T,Ch})\hat{h}_{Ch}{}^{2}}{\hat{N}_{T,Ch}{}^{4}} - var(\hat{h}_{Ch})\frac{var(\hat{N}_{T,Ch})}{\hat{N}_{T,Ch}{}^{4}} \tag{22}$$

The variance of $\hat{F}_{co}$ will be estimated by

$$var(\hat{F}_{co}) = \frac{1}{N_{T,co}{}^{2}} var(\hat{h}_{co}) \tag{23}$$

The variance of $\hat{F}_{sh}$ will be estimated by

$$var(\hat{F}_{sh}) = \frac{1}{N_{T,sh}{}^{2}} var(\hat{h}_{sh}) \tag{24}$$

where

$var(\hat{h}_{Sp})$ = estimated variance of the freshwater Chinook or coho salmon harvest or steelhead catch as reported by SWHS.

SCHEDULE AND DELIVERABLES

Results of this study will be reported as an Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series report. The report will be available after the 2024 season.

Dates	Activity
1 May–13 May	Install field camp and begin operating weirs on each fork.
13 May–7 July	Chinook salmon beach seine surveys.
Early May–mid-June	Install south fork video weir (pending river levels).
August–October	End Chinook salmon enumeration and transition to counting coho salmon and steelhead.
Late October to early November	Remove weirs and close up field camp.
December–March	Anchor River 2020–2024 scale ageing, and preparation of FDS Report

RESPONSIBILITIES

Mike Booz, Fishery Biologist III, Project Supervisor

Duties: Manages budget and overall project supervision. Responsible for annual Federal reporting requirements. Collects timesheets and leave slips for submission. Assists with installations, removals, and beach seine surveys. Makes discretionary decisions concerning safety, methodology, and collection of field samples. Reviews final report.

Holly Dickson, Fishery Biologist II, Project Leader

Duties: Writes project operational plan and final report and supervises daily activities of field crews and data management. Hires seasonal field staff. Coordinates crew schedules as needed with the project field leader. Participates in field activities and supervises the installation and removal of the ARIS and video weirs. Conducts data analyses and summarizes results.

Kaitlyn Manishin, Fishery Biologist I, Project Field Leader

Duties: Works under the supervision of the project leader and supervisor. Responsible for leading technicians with the daily operation of the ARIS and video weirs. Troubleshoots ARIS and video system, directs field crew, procures equipment, and is responsible for the fabrication of the field station. Ensures data are collected and recorded as outlined in the operational plan. Ensures data are reviewed for completeness and error checking inseason. Coordinates weir crew schedules and communicates field needs with project supervisor and leader. Determines scale ages. Conducts data analyses and summarizes results. Co-authors final report.

Teresa Fish, Fishery Technician III; Kim Schuster, Fishery Technician III

Duties: Works under the general supervision of the project leaders and field leader. Supports the daily operation of ARIS and video. Assists with the installation, operation and removal of the ARIS and video systems. Assists with beach seine surveys. Assists with finalizing data post-season, updating the FDS data tables, and finalizing report edits.

Gaylynn Mertz, Fishery Technician II; Vacant, Fishery Technician II non-permanent seasonal

Duties: Works under the general supervision of the project leader. Responsible for operating sonar and video weir. Collects and records data as outlined in the operational plan. Maintains the field camp. Assists with beach seine surveys.

James Miller, Fishery Biologist III, ARIS Consultant

Duties: Provides ARIS operation training and support to project personnel. Provides technical assistance regarding ARIS set-up, operation, and trouble-shooting.

David Evans, Biometrician III

Duties: Provides technical assistance with statistical procedures and sample designs. Reviews and recommends procedures for data analysis. Edits technical Fishery Data Series Report.

BUDGET SUMMARY

Projected costs for each of FY2020–FY2025 Costs

Line item	Category	Budget ($K)
100	Personal Services	87.3
200	Travel	0.0
300	Contractual	0.4
400	Commodities	7.0
500	Equipment	0.0
Total		94.7

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APPENDIX A: ARIS PROTOCOLS

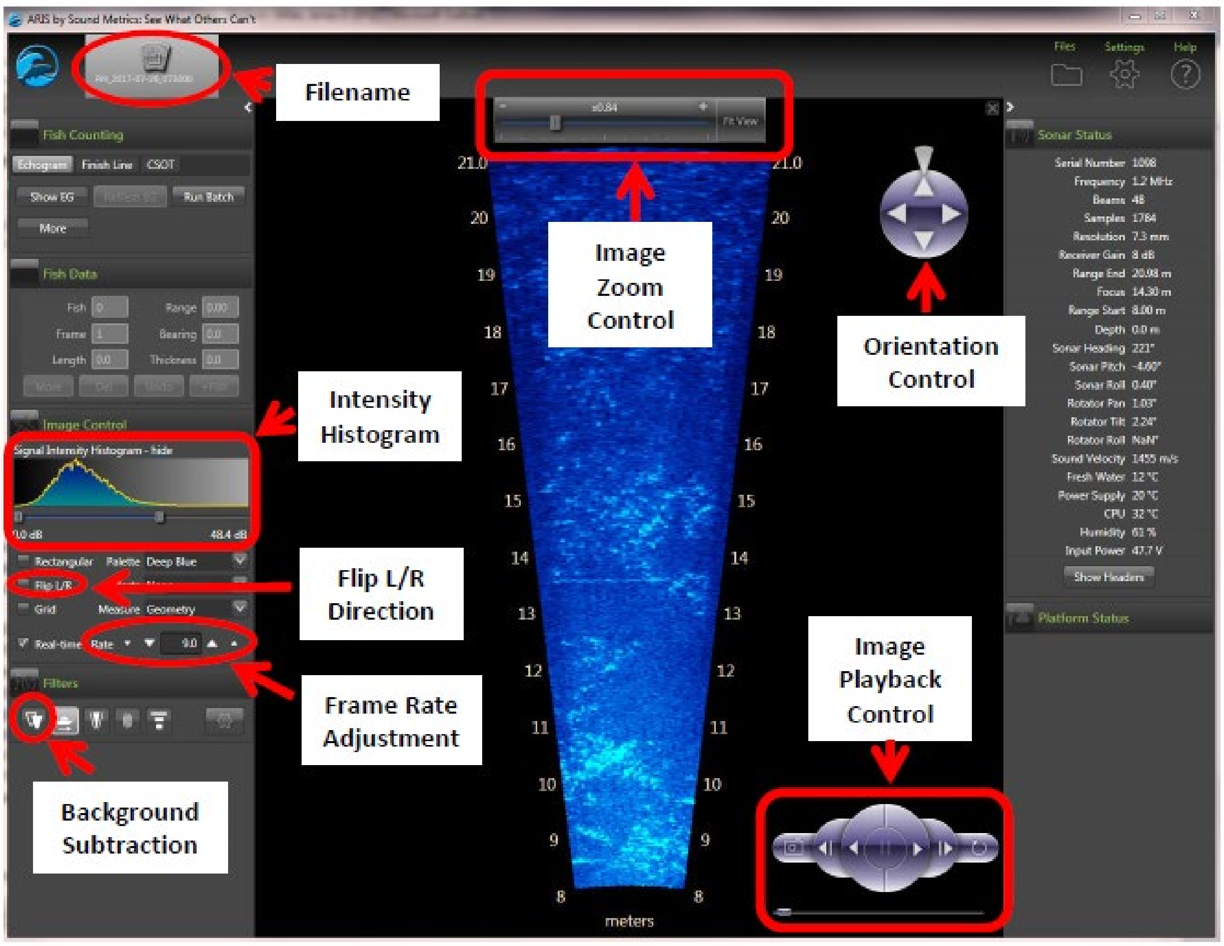
ARIS 1200 Specifications

Detection Mode
Operating Frequency 0.7 MHz
Beamwidth (2-way) 0.8° H by 14° V
Source Level (average) ~216 dB re 1 μPa at 1 m
Nominal Effective Range 80 m

Identification Mode
Operating Frequency 1.2 MHz
Beamwidth (2-way) 0.5° H by 14° V
Source Level (average) ~206 dB re 1 μPa at 1 m
Nominal Effective Range 25 m

Both Modes
Number of beams 48
Beam Spacing 0.6° nominal
Horizontal Field-of-View 28°
Max frame rate (range dependent) 2.5–15 frames/s
Minimum Range Start 0.7 m
Downrange Resolution 3 mm to 10 cm
Transmit Pulse Length 4 μs to 100 μs
Remote Focus 0.7 m to max range
Power Consumption 18 Watts typical
Weight in Air 5.5 kg (12.1 lb)
Weight in Water ~1.4 kg (3 lb)
Dimensions 31 cm × 17 cm × 14 cm Depth rating 300 m
Data Comm Link 100BaseT Ethernet or HomePlug
Maximum cable length (Ethernet) 90 m (300 ft)
Maximum cable length (HomePlug) 300 m (1000 ft)

1) Begin by making a copy of the first 20-minute file of each hour that needs to be counted onto another hard drive. Properly eject that hard drive and plug it into a new computer to conduct the counting.
2) Open the ARISFish counting software and maximize the window to fit your screen (see screenshot below).
3) Click on the file icon in the upper right corner and then select “Recently Recorded Files.”
4) Select the file you wish to count.
5) You can adjust a number of settings, including which setting you’d like to use to count the file (video or Echogram). See ARISFish counting instructions for details.



6) To process the next file, press *Alt+Right Arrow* or click the “File” icon in upper right corner of window to navigate to the next file using the file browser.
7) When done counting a file, note the upstream and downstream totals by navigating to the text file saved with the same name as the .aris file.
8) Enter the upstream and downstream totals in the Sonar Data Entry form (see Appendix B2).
9) Enter upstream and downstream totals in the Deep Creek Access field database.
10) Repeat the process for within- and between-reader counts, entering those counts under the appropriate count type in the Access database.

APPENDIX B: DATA SHEETS

Appendix B1.–Data sheet for recording Chinook salmon data from sonar monitoring.

Anchor River South Fork Sonar

First count

Date ________

Hour	Up	Down	Net	Expanded	# min	initials	Comments
0000							
0100							
0200							
0300							
0400							
0500							
0600							
0700							
0800							
0900							
1000							
1100							
1200							
1300							
1400							
1500							
1600							
1700							
1800							
1900							
2000							
2100							
2200							
2300							

Daily Totals (expanded)

Up	0
Down	0
Net	0

Appendix B2.–Data sheet for recording Chinook salmon data from video weirs.

Video Weir Data Entry Form

Crew: Date: Location:

Hour	Wild			Hatchery		
	Large	Medium	Small	Large	Medium	Small
0000						
0100						
0200						
0300						
0400						
0500						
0600						
0700						
0800						
0900						
1000						
1100						
1200						
1300						
1400						
1500						
1600						
1700						
1800						
1900						
2000						
2100						
2200						
2300						
Total						

3AM reviewed? __________

Wild Total:

Hatchey Total:

If full record needed, note which hours: ______________________ and when completed: ________ by: ____________

walked/ fish tight?

Chinook Total:

Video uploaded to OneDrive? ______

Counts entered in Access and OneDrive? ______

	Initial Check		Final Check	
	Date	Staff	Date	Staff
Datasheet proofed:				
Access proofed:				

Large male: ≥711mm TL, Medium male: ≥508mm and <711 mm TL, Jack: <508 mm TL

Appendix B3.–Data sheet for recording other species data from video weirs.

Other Species Daily Summary

Crew: Date: Weir:

Hour	Species						
	Steelhead Down	Steelhead Up	Dolly Varden	Pink salmon	Coho	Chum	Sockeye
0000							
0100							
0200							
0300							
0400							
0500							
0600							
0700							
0800							
0900							
1000							
1100							
1200							
1300							
1400							
1500							
1600							
1700							
1800							
1900							
2000							
2100							
2200							
2300							
Total							

Appendix B4.–Data sheet used for recording Chinook salmon biological and other species data during beach seine surveys.

Netting Data Form		**Date:**	
Location:	**Crew:**		**Page # _______of_______**

Set #	Sampler	W/H	F/M	L/M/S	MEF Length	Color	Scale			CWT/ Otolith	Sea lice?	Other Species
							Box	Collection	Card			
												Steelhead
												M
												F
												Dolly Varden
												Pink Salmon

Appendix B5.–Data sheet to track generator use, charge of battery systems, and solar system use.

Equipment log											
			Battery Box		Solar		Generator				
Date	Time	Crew	Run time (hrs)	% or volts	on? Total hrs run	watts produced	Times ran	# hours run	# hrs since service	Comments	

APPENDIX C: DATA ENTRY

Appendix C1.–Anchor River ARIS field data fields.

ARIS		
Header Table		
Field Name	Data Type	Description
ARISHeaderID	AutoNumber	Unique number assigned for each day
Date	Date/Year	
Year	Number	Year the data was collected
CountTypeNew	Number	1=First Count (the sum of these counts are used to estimate abundance)
CountingSoftware	Number	1=ARIS; 2=Echotastic
DataComments	Memo	Notes related to the operation of the ARIS for the day
ARISCountTbl		
Field Name	Data Type	Description
ARISHeaderID	AutoNumber	Header number assigned for each day
ARISCountID	AutoNumber	Unique number assigned for each record
FileName	Text	Filename is automatically assigned by ARIS software using the following convention: YYYY-MM-dd-hhmmss_FF.DDF Where yyyy=year; mm=month; dd=day; hh=hour; mm=minute; ss=seconds; ff=frequency (HF= high and LF=low); DDF=ARIS software. Note, military time is used. Example: 2017-05-29-192000_HF.DDF
HourSegCounted	Number	20 minute segment counted (1=first 20 min; 2=second 20 min; 3=third 20 min; 4= full hour counted)
CountWindow	Text	ARIS counting window length (e.g. 1-10 m)
MinCounted	Number	Total number of minutes within the hour counted. Typically, this is should be equal 20 minutes. In case of a malfunction, less than 20 minutes maybe counted.
Upstream	Number	Total number of fish counted upstream
Downstream	Number	Total number of fish counted downstream
NetCount	Number	Upstream – Downstream counts
ExpandedCount	Number	NetCount (60 minutes/minutes counted)
Crew	Text	First and Last name of person who counted
HourComments	Text	Notes related to the hour counted

Appendix C2.–Anchor River video counts and sampling data fields.

Fish Table		
HeaderDataTbl		
Field Name	**Data Type**	**Description**
ID	AutoNumber	Unique number assigned for each day
Date	Date/Year	
HID	Number	Location fish were sampled or counted 1=North Fork 2=South Fork 3=Mainstem
Comments	Text	Comments that would affect counts for the day, i.e. interpolations needed, or no chinook salmon counted but all video reviewed
Crew	Text	Tech on duty that day
FishDataTbl		
Hour Counted	Number	Hour the fish was counted through the weir
Year	Number	Auto filled
Date	Date/Time	Date of sampling
Hour	Number	Hour fish passed through the weir (0000 = midnight; 0100 = 1am…1200 = noon etc).
Species	Number	410=Chinook salmon
NoFish	Number	Number of fish counted
Adfin	Number	0 = adipose absent; 1 = adipose present; 2 = unknown
Size	Text	Small <508 mm TL; Medium ≥508 mm and <711 mm TL; ≥711 mm TL
AdChecked	Number	0=Did not examine fish for presence of an adipose fish; 1= fish was examined
HourComments	Text	Notes related to the hour counted

-continued-

Appendix C2.–Page 2 of 2.

OtherSpecies Table		
Species	Number	420=Sockeye salmon 430=Coho salmon 440=Pink salmon 450=Chum salmon 530=Dolly Varden 540=Steelhead 541=Rainbow trout 600=Pacific lamprey 900=Unknown or other (if “900” is entered, an explanation should be included in the comments.
Date	Date/Year	Date counted
Location	Number	1 = North Fork; 2 = South Fork
Steelhead Up	Number	Number of steelhead moving upstream
Steelhead Down	Number	Number of steelhead moving downstream
Dolly Varden	Number	Number of Dolly Varden moving upstream
Pink salmon	Number	Number of pink salmon moving upstream
Rainbow trout	Number	Number of rainbow trout moving upstream
Coho salmon	Number	Number of coho salmon moving upstream
Sockeye salmon	Number	Number of sockeye salmon moving upstream
Chum salmon	Number	Number of chum salmon moving upstream
Lamprey	Number	Number of lamprey moving upstream
Other	Number	Number of other moving upstream

Appendix C3.–Biological sampling data structure.

Beach seine data		
Date	Date/Year	Date sampling occurred
Species	Number	410 = Chinook 420=Sockeye salmon 430=Coho salmon 440=Pink salmon 450=Chum salmon 530=Dolly Varden 540=Steelhead 541=Rainbow trout
NoFish	Number	Number of fish
Sampler	Text	Initials of sampler
Adfin	Number	0 = wild, 1 = hatchery
EF	Number	Mid-Eye to Fork length in mm
Size	Text	Small <508 mm TL; Medium ≥508 mm and <711 mm TL; ≥711 mm TL
Sex	Number	1=Male 2=Female 0=Unknown
Color	Number	1=Chrome; 2=Pink or Blush; 3=Bright red to Maroon
Sea Lice	Text	Present or absent
Scale Box	Number	Scale box used in the field
Card	Number	Gum card number scales mounted to
Col	Number	Column number (1…10)
CWT #	Number	Unique number attached to the head of a sacrificed fish
Otolith Collection	Number	Collection and storage number of otolith
FishComments	Memo	Notes related fish counted or samples
Set	Number	1 to n+1 (Holes are numbered from upstream to downstream with 1 being the furthest upstream hole.
Location	Text	Start and end locations of survey

APPENDIX D: CREW SCHEDULE

Appendix D1.–Anchor River weir crew schedule outline, 2020–2024.

Name	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
FWT-II (A)	X	X	X	X			
FWT-II (B)				X	X	X	X

Note: Duty days may change pending project needs.

Daily Duties

- 0800–noon — Finish previous day's counts, enter in database, and update season summaries. Watch 3:00 AM hour for current day, then motion triggers.
- noon–1300 — Visit weirs to check fish tight and clean glass. Run south fork generator if needed.
- 1300–1500 — Proof data, service generators, camp maintenance, fill up gas, assist with other projects.
- 1900–2100 — Catch up counting to current time; make sure power supply is sufficient overnight at south fork

Thursday Schedule

- Mon–Thurs tech — 0800–noon: weir and counting
  Noon–1600: netting and maintenance
  1600: off duty
- Thurs–Sun tech — Noon–1600: netting and maintenance
  1800–2300 weir and counting

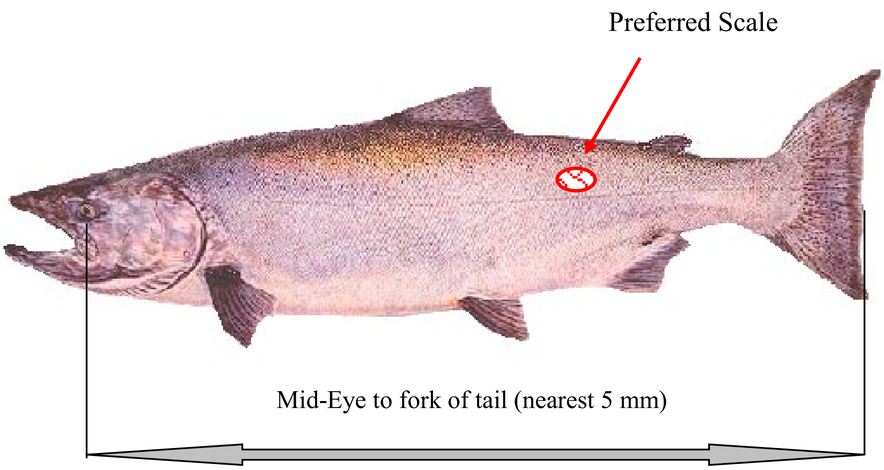
Maintenance includes servicing generators, water exchanges, gear repair, and camp improvements.

Other duties and schedule

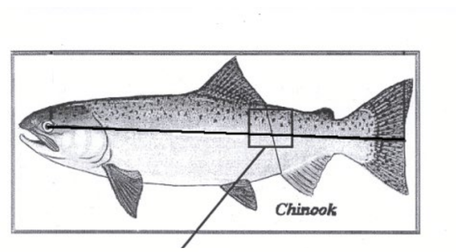
- Maintain a work schedule of 37.5 h/week. Thursday schedule will be adjusted if counting consumes more time than available above.
- Communicate with project leaders if counting takes more or less time than time above.

APPENDIX E: SCALE SAMPLING PROCEDURES

Appendix E1.–Scale and length sampling procedures, Anchor River.

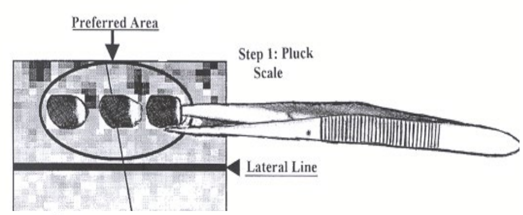


Preferred scale is located on the left side of the fish, two rows above the lateral line along a diagonal line from back (posterior) of the dorsal fin to the front (anterior) of the anal fin.



Pluck the "preferred scale" from the fish using forceps.

Pliers may be necessary to remove scales if the fish has been in freshwater for an extended period.



Remove all slime, grit and skin from scale by moistening and rubbing between thumb and forefinger. Moisten the clean scale and mount it on the gummed card directly on top of the number "1".

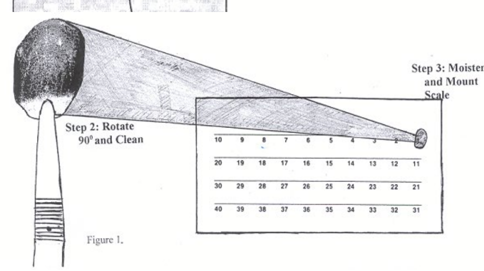
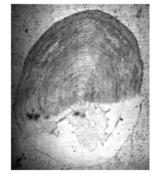


Figure 1.

-continued-

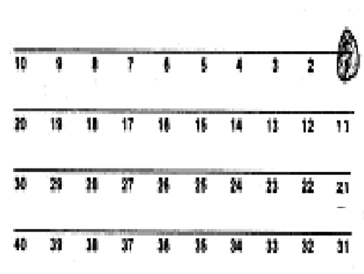
A good scale has a well-rounded shape.

Hold scale up to light and examine for overall size, shape, regeneration, deformities, etc.

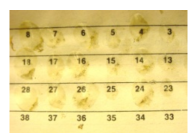


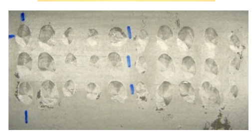
When sampling Chinook salmon take three scales per fish. Mount scale from fish # 1 over the numeral "1, 11, and 21".

Continuing, to mount the one scale from fish #2 over the numerals "2, 12, and 22" and so on…



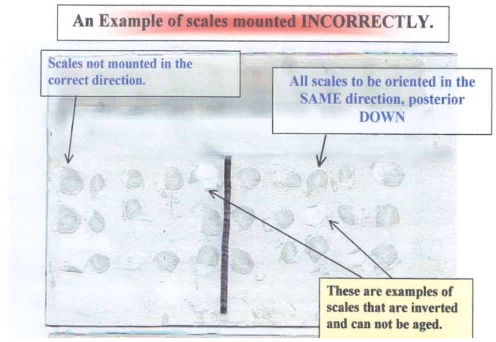
After the scales are mounted on the scale gum cards they are pressed onto acetate



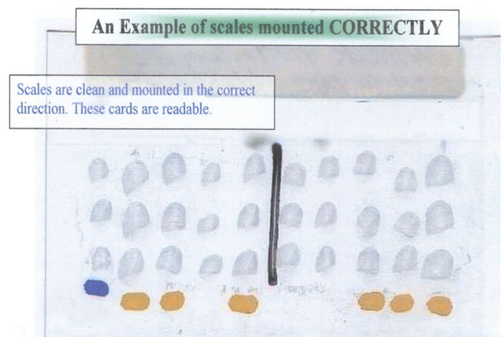


-continued-

Incorrect scale mounting



Correct scale mounting



Common problems encountered with inexperienced scale collectors are torn edges, inadequate scale cleaning, selecting regenerated or distorted scales, inverted scale mounting, and dirty gum cards. Common data recording errors include recording the scale number for the sample number, incorrect number of scale samples collected than recorded, and more than one fish with the same collection number. The following steps should help resolve these problems:

1) Experienced staff must take extra measures to ensure that less experienced staff become fully proficient at sampling before the first sampling event. Before the first sampling event, take 1 fish and slowly walk through the sampling routine with less experienced crew. This routine should specifically demonstrate the sampling process (below).
2) Locate the lateral line and preferred scale sampling area.
3) Identify irregular scale patterns that are the result of regenerated scales.
4) Remove the scales in a manner that reduces torn edges.
5) Properly clean and mount scale samples.
6) Identify inversely mounted scales.

Minimize the handling of gum cards and keep them as dry as possible. Wet gum cards should be dried out slowly. Excessive heat when drying may cause the scale to become unglued from the gum card. After the gum cards are dry, they should be stored with wax paper between each gum card. Check the numbering between the access database and the gum card.

A final step to improve quality is to identify sampling problems promptly so that corrections can be implemented in season. To achieve this, gum cards should be sent to the Homer office as quickly and as often as possible throughout the season. Homer staff will press the scales and review and examine the scales for sampling problems. The person who collected the scales needs to be identified on each gum card so that feedback can be effectively directed to the source.

Reader Verification

Readers will review a test set of 50 scale samples from both Chinook and coho salmon. The test set contains scale samples from 2003 through 2007 for each species from various locations. Chinook salmon scale samples will include some fish of a known age. Readers' test-set ages will be compared to previous age estimates and known ages. Ages that do not match will be reviewed and re-read. Once the reader ages are resolved, then the reader will begin with the collected samples from the present season.

Scale Interpretation and Criteria

To estimate scale age, at least 1 scale per sample must have the following:

1) A clean focus.
2) Little or no regeneration in the freshwater growth.
3) Minimal tearing on the edge.
4) Clearly identified annuli through winter growth periods and crossing over of rings.

If none of the scales for each sample does not contain all of these characteristics, then the age will be recorded as "NR" (not readable). Samples with differing scale age estimates (i.e., scale 1 = 2; scale 2 = 2; scale 3= 1) will be recorded as "NR."

A large number of scales have been collected from the projects. It is better to reject a fish from the sample than to use questionable scales.

APPENDIX F: CODED WIRE TAG SAMPLING PROCEDURES

USE THE CINCH STRAPS SEQUENTIALLY. Fill out a Coded Wire Tag Sampling Form (Appendix F2). In the Sampling Information section, write the total number of fish that were let above the lower weir that day and the total number with adipose finclips. Store and organize all completed forms in the appropriate folder. These steps will minimize confusion during data editing.

Fields on the Coded Wire Tag Sampling Form are to be used as follows (refer to Appendix F2):

1) Page of Pages. Begin with page 1 each day. If more than 1 page is needed that day, they should be numbered sequentially from the beginning of the day.
2) Sample Number = 20DU2_ _ _. The spaces should be numbered sequentially 1 to n + 1. The first number, “20”, is the year.
3) Source. Circle "Escapement-survey” for weir and netting data, “sport” for sport harvest.
4) Survey Site. Write "Anchor River."
5) Sample Type. Circle "random" for heads collected during your sampling day.
6) Sampler. Write your full name
7) Date Sampled. Write the month and day of sampling using leading zeros.
8) Sampling Information.
    a. Total # Fish Checked for Ad-clips. This is the number counted by species with or without an adipose fin; count only those fish you are sure either have or do not have an adipose fin. If you do not get a good look at the fin, do not count that fish.
    b. # AD-Clips Seen. Total number of fish with a missing adipose fin.
    c. Were All Checked? Circle “y” if all of the Chinook salmon were checked for the presence of an adipose fin.
9) Area Informaiton
    a. Anchor River is 244-70
    b. Name of place surveyed: stream (Anchor River)
    c. Water Type. Circle freshwater
    d. Anadromous stream #: 244-10-10010
10) Head Recovery Information.
    a. Check Box. Do not check.
    b. Head Number. Write cinch strap number.
    c. Species Code. 410 or 411
    d. Length. Write the mid eye to tail fork length to the nearest 5 millimeters.
    e. Y or N
    f. Sex. Write "F" for female and "M" for male.

Appendix F2.–Coded wire tag data entry form for the Anchor River.

Alaska Department of Fish and Game

Coded Wire Tag Sampling Form

Rack Return and Escapement Survey

South Central, Westward and AYK Regions

Page Info for this Sample Number only! See Instructions

PAGE ___ OF PAGES ___

SAMPLE NUMBER: 1 1 D U 2

SOURCE: (circle one) rack return escapement survey

SURVEY SITE: Anchor River

SAMPLE TYPE: random select

SAMPLER: ________

DATE SAMPLED: __ - __ - YY

SAMPLING INFORMATION

This Box to be completed for RANDOM Samples Only

SPECIES (CODE)	TOTAL # FISH CHECKED FOR AD-CLIPS	# AD-CLIPS SEEN	WERE ALL CHECKED?
(410)CHIN			y n
(411)JACK CHINOOK-ONLY			y n
(420)SOCK			y n
(430)COHO			y n
(440)PINK			y n
(450)CHUM			y n
(540)STHD			y n

AREA INFORMATION (DISTRICT - SUBDISTRICT)

OTHER DISTRICTS

231- 245- 331-

241- 246- 334-

244-21 247-

NAME of PLACE SURVEYED: (HATCHERY OR STREAM) Anchor River Weir or Netting

WATER TYPE: saltwater freshwater

ANADROMOUS STREAM# (FRESHWATER-ONLY) 244-10-10010

HEAD RECOVERY INFORMATION

✓	HEAD NUMBER	SPECIES CODE	LENGTH (mid-eye to fork in mm)	CLIP	SEX

COMMENTS